ILLUMINATING ENGINEER

XXIV | February, 1932 | Price 9d.

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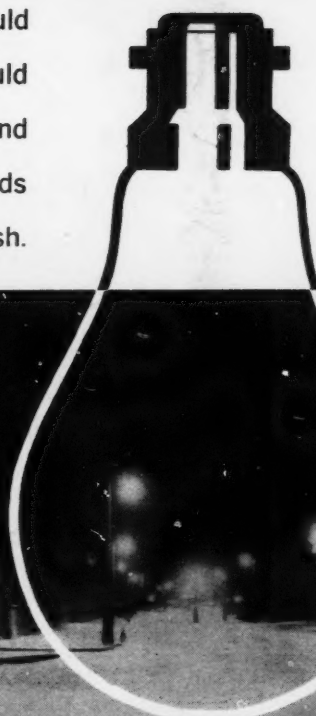

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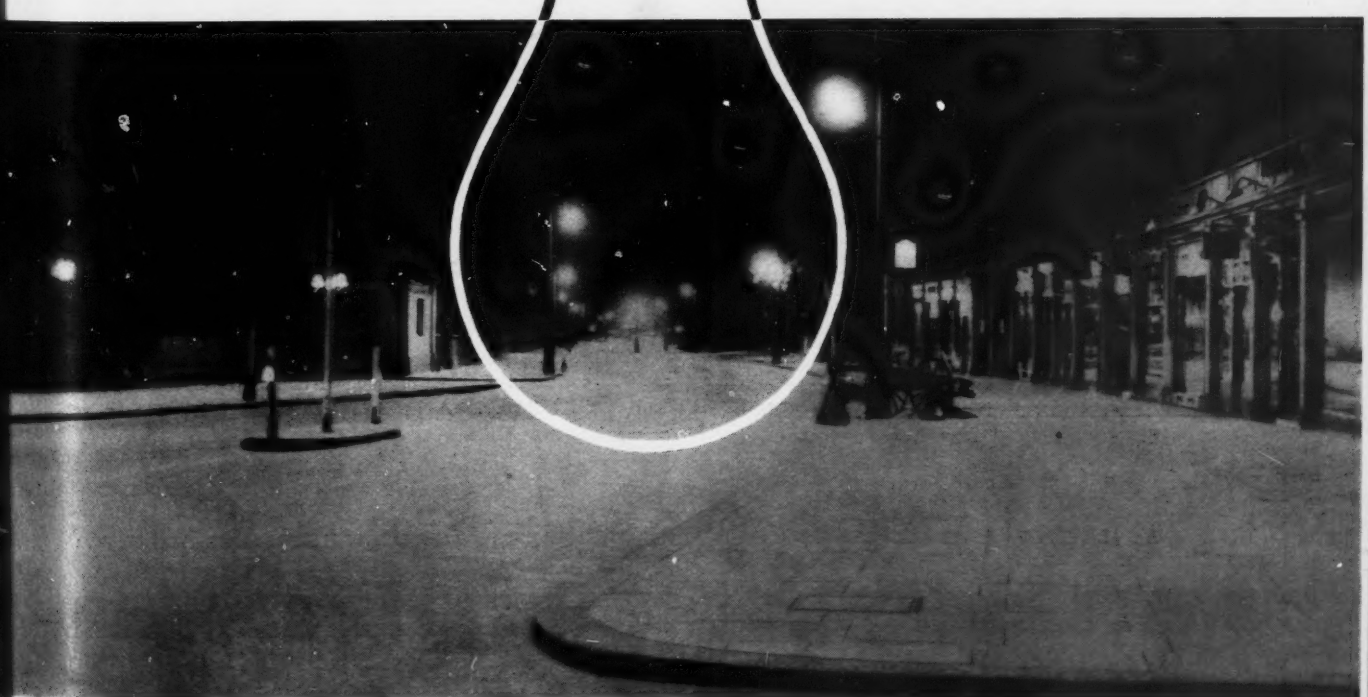

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OFFICIAL JOURNAL of
The Illuminating Engineering Society
(Founded in London, 1909, Incorporated 1930)
and of
THE ASSOCIATION OF PUBLIC LIGHTING ENGINEERS
(Founded 1923; Incorporated 1928)

Vol. XXV | February, 1932 | Price NINEPENCE
Subscription 10/6 per annum, post free.
For Foreign Countries, 15/- per annum.

Edited by
J. STEWART DOW

EDITORIAL AND PUBLISHING OFFICES:
32 VICTORIA STREET, LONDON, S.W.1.
Tel. No.: Victoria 5215

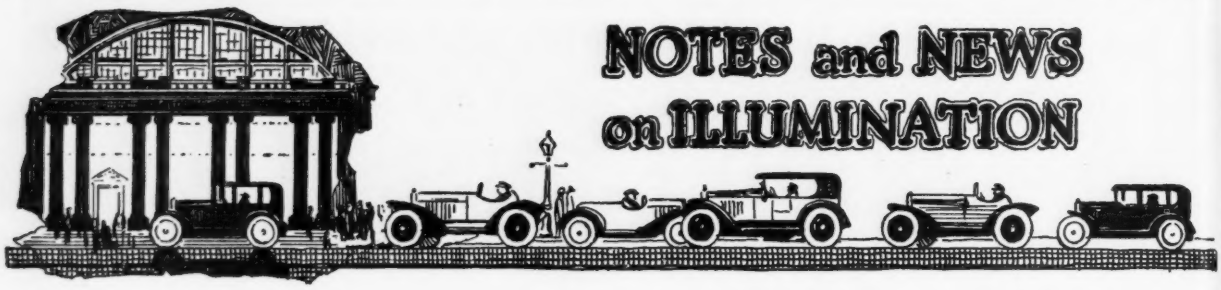
Floodlighting Again

WE have some sympathy with the apprehension excited by the proposal to project luminous advertisements or writing on the clouds by means of gigantic magic lanterns. Scintillating signs in our cities are perhaps inevitable. But we share the desire expressd by Sir Herbert Baker in a recent letter to *The Times*, that the "canopy of heaven above" should be kept free from advertisements. Perhaps it is as well that climatic conditions in this country would in any case set a limit to such efforts.

The greater part of Sir Herbert Baker's letter, however, was not concerned with this somewhat fanciful project, but with floodlighting. Like others, he praised the natural floodlighting effects of the sun and moon, but condemns artificial lighting, partly, it would seem, because brilliant floodlighting of a particular building tends to make other adjacent things visible with difficulty, and partly because of the so-called two-dimensional "pasteboard effect," which is sometimes in evidence. These are only two of a number of objections occasionally raised by artists and architects to floodlighting. Some of these objections would seem to be mutually conflicting, and many of them are, in a measure, the expression of a sense of novelty and consciousness of unfamiliarity in the effects produced. What these critics should realize is that when buildings are seen by night *at all* it is almost invariably by such artificial light as exists—bright moonlight nights, and even star-spangled skies, in this country being the exception. Why not, therefore, accept the existence of this artificial light and consider how it can best be applied? In other words, why do not those who are gifted with artistic perception become leaders of the movement to make better use of artificial light instead of fruitlessly opposing it?

What is needed, now that the public has become interested in the existence of floodlighting, is critical analysis of its possibilities. It may be that some of the buildings in London were overlighted—or rather that the scale of brightness deliberately adopted during the Congress was unduly high for a permanent installation. If so, let us ascertain, by consultation with architects and artists, the range of brightness that should be aimed at in order to produce a natural rather than a theatrical effect. (We speak here, of course, of the illumination of buildings of architectural distinction rather than the floodlighting of commercial buildings for purposes of advertisement.) Let us also establish once and for all what are the factors that produce the "pasteboard" effect of which architects are apt to complain. An appearance of flatness or monotony may be due to the method of lighting; but is quite possibly attributable to the nature of the surface illuminated. (At the meeting of the Illuminating Engineering Society on October 30th, Mr. Ritchie's demonstration of the singular difference in the appearance of Buckingham Palace produced by merely drawing up the blinds was instructive in this respect!) There are few buildings which do not tend to look uninteresting in some form of natural light. In the author's experience, the feeble illuminations produced by moonlight are particularly apt to produce the strange unreal two-dimensional appearance to which objection has been taken. People are apt to recall with enthusiasm some enchanting view of a tower seen in the rays of the setting sun; they ignore the dreary impressions on many wet and cloudy days. (At the moment, the writer, by moving a few steps, can see the towers of Westminster in a soft halo of golden light; but how often are they thus seen? More often they are partially obscured by mist or seen dimly through a rain-laden atmosphere.)

There is really little that cannot be done by artificial light, which, unlike daylight, is under strict control, if only the conditions to be aimed at are defined and there is goodwill in affording the necessary equipment and facilities. Mr. Howard Robertson, in a recent paper read before the Royal Institute of British Architects, commented upon the transformation effected in certain sections of London by the floodlighting of September last. He also emphasized one important advantage possessed by artificial light in contrast to daylight—the power of selection. The sun and moon shed their rays on the just and unjust alike, on slum areas and boulevards, on bad architecture as well as fine buildings. But when artificial light is applied we have power to select what shall be revealed and what shall be mercifully hidden. The best service that those with artistic perceptions can do is, as we have said above, to guide these efforts to use artificial light. It is idle in this age to imagine that great cities can return to reliance on the light of the moon. More and more artificial light will certainly be used by night. Let artists and architects see to it that this light is not applied exclusively for commercial purposes, and that at least a portion is used to enhance the appearance of cities by night.



Church Lighting

Following the annual dinner of the Illuminating Engineering Society, on February 9th, the next item, on February 19th, will be devoted to a discussion on "Church Lighting." This meeting, which will be held in the house of the Royal Society of Arts at 6-45 p.m., takes the place of the "problems" meeting usually arranged in February. On this occasion a series of contributions by different authors will deal with a special class of problems, namely, those met with in the lighting of churches of different denominations. Arrangements have been made for several interesting introductory addresses, but the meeting is specially intended to afford opportunities for other members to narrate their experiences. The Hon. Secretary would therefore be glad to hear from any members who can present records of interesting installations, or who would like to join in the discussion.

Factory Lighting in Relation to Safety

There was an excellent attendance at the meeting arranged by the National Safety First Association on January 11th, when an address was given by Mr J. S. Dow on the above subject. The meeting was held in the lecture theatre of the Home Office Industrial Museum, visitors afterwards inspecting the lighting exhibit in the basement. Mr. Dow mentioned numerous forms of accidents liable to be caused by inadequate lighting conditions, and emphasized the importance of the indirect losses arising from accidents which are not usually covered by insurance. In the discussion the Illuminating Engineering Society was represented by Mr. J. G. Clark and Mr. Stroud, and pertinent points were raised by managers of factories and others engaged in industrial work. Amongst these special interest attaches to the comments of Mr. MacAdam and others on the growing importance of strong local illumination, especially where general lighting does not readily penetrate to important parts of complex machinery. It was suggested that makers of machinery and machine tools might well consider the provision of local lighting units at the correct points as an essential element in the general design, and also that the effects of light would be aided materially if they would agree to paint the inactive portions of machines in a light grey colour instead of black.

The British Standards Institution

The British Standards Institution (formerly the British Engineering Standards Association) sends us the 1932 edition of the Indexed List of British Standards Specifications (price 1s. 2d. post free), which aptly illustrates the constant expansion of the Institution's work. Attention is drawn in a separate leaflet to the terms for membership, which is open to all British subjects, technical and trade associations, local and public authorities. All particulars are obtainable from the Publications Department, 28, Victoria Street, London, S.W.1.

Modern Lighting on the Great Western Railway

An article under the above title in a recent issue of the *Great Western Railway Magazine* illustrates the interest being taken in lighting on the Great Western Railway—particularly floodlighting, which has been the subject of experiments from 1925 onwards. There are now about 200 projectors in use for the illumination of goods-yards and large open spaces. The projectors, which are specially designed to withstand rough conditions and inclement weather, are usually mounted at heights of about 40 ft. on the "parallel opposed" system—a substantially lower height than that adopted abroad, where the uni-directional system is more frequently used. Floodlighting in railway goods-yards has had excellent results in speeding up work, lessening damage and accidents, and diminishing losses due to pilferage. Different methods are naturally requisite for railway platforms, where opal dispersive fittings (such as those used at Paddington Station) have been found to answer well. One interesting development on certain Continental locomotives is the provision of permanent built-in local lighting units to facilitate the inspection of moving parts. In many places gas lighting is used, one specially favourable instance being the Reading Station subway, where the concealed gas lighting of the posters is distinctly effective.

Public Lighting and Safety

The remarks of the North London Coroner, in connection with a recent fatality in Walthamstow, have been widely quoted in the press to illustrate the need for better public lighting. It was stated that the accident occurred at a place where the woman, who was dressed in black, was crossing between two "pools of light." The comments of critics are instructive in that they accept as fundamental principles of good lighting, sufficient illumination, absence of glare and reasonable uniformity of illumination.

At one time the importance of these three points was not nearly so well recognized. Most people now would endorse their value, but it will continue difficult to unite these qualities as long as authorities are content to perpetuate the big spacings of lamps that still prevail. Instead of "uniformity of illumination" it would perhaps be better to say "absence of sudden contrasts in brightness," for the "pools of light," with dense darkness between them, are in no small measure caused by the dark and polished nature of the modern road-surface. Undesirable contrasts may also arise when one passes from a brightly lit main thoroughfare to a dimly illuminatd side street. We cannot agree, however, that main roads are excessively lighted. The contrasts should be diminished not by curtailing the lighting in main roads, but by improving the lighting of side streets (at present often inadequate to a degree).

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Motor-Car Headlights

Proceedings at a Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 6-30 p.m., on Friday, January 8th, 1932.

A MEETING of the Society was held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 6-30 p.m., on Friday, January 8th, when there was a good attendance of members and friends. After the usual introductory period devoted to conversation and light refreshments the meeting commenced at 7 p.m. The chair was taken by Mr. Clifford C. Paterson (Past President), in the absence of the President owing to indisposition. In the course of the evening a message was received from Sir Francis Goodenough expressing his regret at being unable to preside, but wishing members a successful evening.)

After the minutes of the last meeting had been taken as read, the Hon. Secretary read out the names of applicants for membership, which were as follows:—

Sustaining Members:—

The Cardiff Gas Light and Coke Co. (*Representative*: Mr. H. Madden, Bute Terrace, Cardiff.)

The Commercial Gas Co. (*Representative*: Mr. A. E. Williams, Harford Street, Mile End, London, E.1.)

The Kensington and Knightsbridge Electric Lighting Co. Ltd. (*Representative*: Mr. G. C. Weston, 63-68, Pelham Street, London, S.W.7.)

The St. James's and Pall Mall Electric Light Co. Ltd. (*Representative*: Mr. S. H. C. Webster, Carnaby Street, Golden Square, London, W.1.)

The Wandsworth and District Gas Co. (*Representative*: Mr. C. P. E. Thorpe, Fairfield Street, Wandsworth, London, S.W.18.)

Corporate Members:—

Cramb, A. C. .....Director of The British Electrical Development Association, 15, Savoy Street, Strand, London, W.C.2.

Marshall, D. .....Assistant Distribution Engineer, Hong and China Gas Co., Hong Kong.

Thomson, F. G. .....Philips Lamps Ltd., 145, Charing Cross Road, London, W.C.2.

Ward, A. J. .....Technical Department, The British Thomson-Houston Co. Ltd., 158, Ardgowan Road, Catford, London, S.E.6.

Foreign Members:—

Caarenstroom, J. H....Sub-Director of the N.V. Philips Gloeilampenfabrieken, Eindhoven, Holland.

Cohu, M. .....Chief Engineer, Société pour le Perfectionnment de l'Eclairage, 134, Boulevard Haussmann, Paris (8E), France.

Kalff, Louis C. .....Architect, Kievitlaan 12, Eindhoven, Holland.

Kustner, Robert V. ....Electrical and Machinery Importer, Box 1045, Johannesburg, South Africa.

Leblanc, Maurice .....President de l'Association des Ingenieurs de l'Eclairage, 47, Boulevard de Versailles, Suresnes (Seine), Paris.

List, Prof.-Ing. K. ....Technical University, Brno, Czecho-Slovakia.

Maisonneuve, H. .....Directeur de Service d'Edutes et d'Applications de la Compagnie des Lampes, 29, Rue de Lisbonne, Paris (8E), France.

Millar, Preston S. ....The Electrical Testing Laboratories, 80th Street and East End Street, New York, U.S.A.

The Hon. Secretary then read again the names of applicants presented at the previous meeting, and these gentlemen were formally declared members of the Society.*

The CHAIRMAN then called upon Mr. E. S. Calvert to present his paper on "Motor-Car Headlights." This consisted of three main sections (1) discussing the parabolic reflector, its use with linear and other sources of light, and its design; (2) analysing glare and present methods of dealing with it; and (3) considering the nature of the beam desirable to illuminate the roadway adequately and at the same time obviate glare. The paper was illustrated by numerous lantern slides.

An interesting discussion followed, in which Dr. S. ENGLISH, Mr. H. MARTIN, Mr. T. J. SACK, Mr. H. N. GREEN, Major GRAVES, Mr. G. H. WILSON, Mr. L. GRIFFITHS, Col. J. A. PICKARD and Mr. J. A. TRITTON took part. A feature of the discussion was the display by Dr. English and Mr. Martin of two forms of headlights also designed to eliminate glare, but differing in principle from that designed by Mr. Calvert.

After Mr. Calvert had briefly replied to the discussion, a cordial vote of thanks to him for his paper was passed on the motion of the Chairman.

Finally the Chairman mentioned that the next meeting, on Friday, February 19, would be devoted to a discussion on "Church Lighting." He also drew the attention of members to the Annual Dinner of the Society, to be held at the Trocadero Restaurant, Piccadilly Circus, on February 9th.

* *The Illuminating Engineer*, January, 1932, p. 3.

Motor-Car Headlights

By E. S. CALVERT B.Sc., A.R.C.Sc. (Dub.)

Paper read at the Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C.2, on January 8th, 1932.

IN this paper I have approached the problem of a satisfactory motor-car headlight as far as possible from first principles. For the last three years I have been employed on aircraft illumination, and it has often occurred to me that some of the principles which I had found useful in that branch could be applied to motor-car headlights. I have omitted as far as possible matter which can be found in standard works on the subject, and have concentrated on aspects of the problem which appear to me to have received too little attention.

I have divided the paper into three sections as follows:—

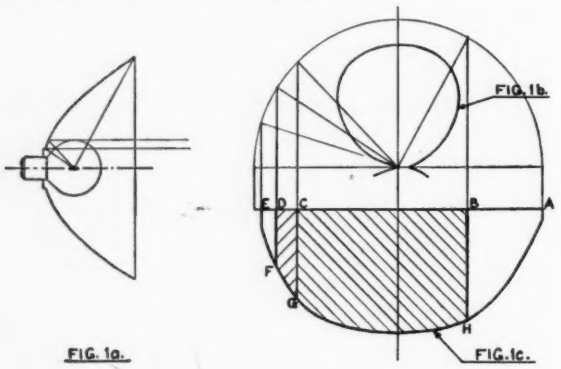
(1) Discussion of the parabolic reflector used with linear and V-sources, touching on a few general points in design.

(2) Short discussion of glare, and a few typical examples of present methods of dealing with it.

(3) Consideration of the type of beam, i.e., shape and intensity distribution, necessary to illuminate the road and at the same time to obviate glare. In conclusion, I will describe a few methods of approximating to the ideal beam, and will state what I consider the best solution of the problem.

(1) *Parabolic Reflector with Linear and V-type Sources.*

Fig. 1A shows a typical headlight for a light car, consisting of a parabolic reflector of 6-in. aperture, and a lamp of 38-mm. bulb diameter with a straight axial filament about ¼ in. long.



TOTAL FLUX	= AREA AEGH	=	100%.
FLUX INTERCEPTED BY REFLECTOR	= " BDFH	=	77·3%
FLUX THROUGH BULB	= " CDFG	=	5·8%
FLUX TOTALLY LOST	= " DEF	=	2·6%
FLUX ISSUING DIRECT	= " ABH	=	20·1%

Fig. 1B is the polar candle-power curve given by such a filament. The flux or Rousseau diagram derived from the candle-power curve is shown at Fig. 1C. The candle-power curve approximates closely to a circle, and the derived flux curve is roughly trapezoidal in shape. The shaded portion of Fig. 1C shows the proportion of the total flux intercepted by the arrangement shown in Fig. 1A. It will be noticed at once that the usual type of headlight is a very efficient piece of apparatus compared with most optical devices. In this example, the light intercepted is about 77 per cent. of the total flux emitted by the lamp.

This shows clearly that very little improvement can be obtained by trying to utilize more of the light flux, as, for example, by increasing the angle of collection of the reflector. Failure to realize this has led to many freak and often expensive designs. One example is furnished by a design having a specially accurate mirror at the back in addition to the ordinary silvered-metal parabolic reflector. This mirror only intercepts a few per cent. of the light flux, and much of what it does intercept is blocked by the bulb, which is mounted from the front. The mirror produces a narrow and intense beam, which, being useless and even objectionable, is spread out by a diffusing front glass, which, of course, removes any possible reason for ever having an accurately ground mirror at all.

The second point of importance is the divergence of the beam. The minimum divergence possible with any projection system is equal to the maximum angle subtended by the source at the reflecting surface in the case of a reflector, or at the equivalent bending surface in the case of a lens system. Fig. 2A shows a graphical method of finding this maximum angle, and the position on the reflector at which it occurs, in the case of a line source on the axis. A circle is drawn by trial through the ends of the filament and touching the reflecting or bending surface. In practice this circle is easily drawn, as one locus for its centre is the perpendicular to the axis at the mid point of the source.

Fig. 2B shows how the method may be applied to finding the divergence produced in a parabolic reflector by a linear source axially out of focus. The circle is drawn through the focus and the end of the source remote from the focus, to touch the parabola. Then the angle subtended at the point of contact by the distance between the focus and the remote end of the source is the semi-divergence of the resultant beam.

Fig. 2C shows the case when the mid point of a short linear source is at the focus of a parabolic reflector. In this case the maximum angle subtended by the source occurs at 60° to the axis. The angle of divergence is very slightly larger than the maximum angle subtended by the source, but for our purpose the difference is negligible. It has been shown mathematically by Mr. J. W. Ryde that the divergence is given closely as 37 l/f degrees, where "l" is the length of the filament and "f" the focal length of the reflector.

Accurate calculations of divergence and distribution, when applied to headlights, are, in my opinion unnecessary, and indicate an absence of scientific method in the person making them. We have all seen papers on headlights where the divergences and distributions produced by spherical, disc, and conical sources are discussed in detail. The application of intricate mathematics to such hypothetical cases can only have an academic interest when it is considered that such sources would never be used owing to expense, and that, in general, the use of diffusing glasses makes accurate calculations meaningless, whatever the source.

Now if the aperture of the reflector and the size of source are fixed, then both the divergence and the angle of collection increase with decrease in focal length. The increased angle of collection is, however, counterbalanced by increased losses on the bulb, roughly speaking, all the reflected light which ought to pass through the bulb is lost to the main beam, either by absorption or by scattering. If the aperture be fixed at, say, 6 ins., then a reflector

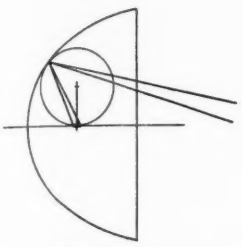


FIG. 2a.

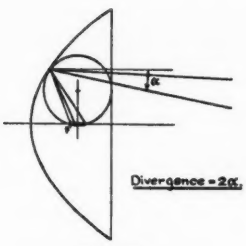


FIG. 2b.

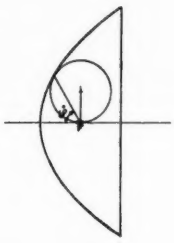


FIG. 2c.

of $\frac{7}{8}$-in. focal length will have an angle of collection of 239°, and used with a linear source $\frac{1}{4}$ in. long will have a divergence when in focus of $10\frac{1}{2}$°. Taking the diameter of the bulb as 38 mm., 5.8 per cent. of the total light flux passes after reflection through the bulb, 71.5 per cent. is reflected into the main beam without obstruction, and 20.1 per cent. issues direct. These may be taken as typical values in this country for the plain parabolic headlight. When spreading prisms are used it is usual to use a longer-focus reflector, with or without the V-type filament.

Now the beam given by a parabolic reflector used with an axial spiral filament is found to be unpleasantly striated. These striations are of two kinds, circular and radial. The explanation, although not generally understood, is very simple. The light patch projected by each elementary area of the reflector has the same apparent size and shape as the source viewed from the elementary area under consideration. In Fig. 3A, the circle on the left

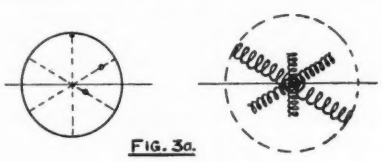


FIG. 3a.

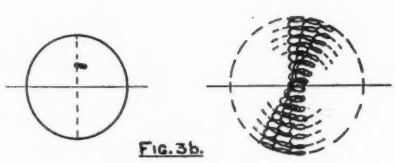


FIG. 3b.

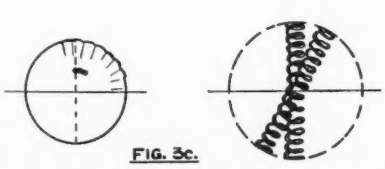


FIG. 3c.

represents the front elevation of a reflector, the three little circles being elementary areas of the reflecting surface. Assuming the middle of the filament at the focus, then if the rest of the reflector is blanked off, these three areas will throw on the screen three light patches, as shown on the right in Fig. 3A. It will be noticed that all the light patches overlap at the centre. At the edge, however, there is no overlapping of the light patches, and the adjacent images of the spiral filament unite to form concentric rings, as shown in Fig. 3B. Striation is always difficult to avoid with spiral filaments, but the single straight axial filament is probably the worst case.

Radial striation, on the other hand, is caused by small regular, axial corrugations in the reflector, as shown in Fig. 3c on the left. Due to the presence of these slight corrugations, two of the four elementary areas throw images, which fall on top of those thrown by the other two, as shown in Fig. 3c on the right, the result being two bright radial lines separated by a dark space. It is clear that pressed reflectors will suffer from this form of striation to a much greater extent than those which are spun. By applying the same method of examination in the case of the V-type source, it will be found that this source is less likely to give striation of either kind, and this is borne out in practice.

Most of the methods of removing striation involve an increase in the angle of divergence, and consequently a change in the distribution. The methods in general use are:—

(1) Diffusing front glass.
(2) Pearled bulb.
(3) Local modifications to the contour of the reflector, i.e., regular flats, either axial or vertical.

Of the above (1) is by far the most common, and, in my opinion, is a bad solution. In Fig 4 is shown the effect of diffusing glasses on the distribution. Curve A is a typical beam of about 8° divergence, given by a parabolic reflector without modification. Curve B is the beam from the same reflector modified by a diffusing glass such that the divergence is increased by about 3°, while Curve C shows the effect of a glass which nearly doubles the divergence of the original beam. It will be seen that diffusing glasses greatly reduce the maximum candle-power, and increase the divergence considerably just where such an increase is likely to cause most trouble to an approaching driver. In addition, a larger proportion of the light flux is lost in the upper air. The effect of "pearling" the bulb is very similar to that of diffusing glasses. Flats on the reflector remove striation without greatly increasing the divergence, but the method is too expensive for general use.

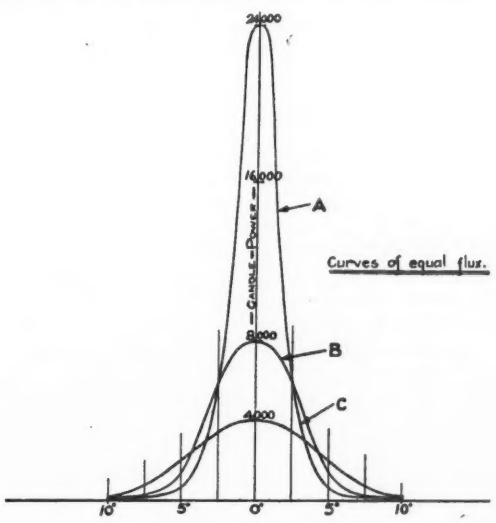


FIG. 4.

If any of the above methods is used, it follows that accurate reflectors and precise focussing are unnecessary. It is surely an absurdity for anyone to claim that reflectors are as accurate as modern

engineering methods can produce, and focussed to a minute fraction of an inch, and then to increase the divergence by diffusion. It would be much more to the point to claim that the silvering was good and the lamps weatherproof.

In the foregoing we have considered the parabolic reflector with reference to the single straight spiral filament. The V-type of filament located so that the V lies in the horizontal plane is, however, coming into use, and in my opinion has marked advantages. The beam, as mentioned before, is less striated, and the intensity distribution is more even. The latter effect, together with the reduced divergence obtained by using the V-type filament, make it eminently suitable for use with spreading prisms.

Before leaving this section of the paper I would like to make a few remarks on the question of sidelights. Sidelights are really navigation lights, and their function is to indicate the presence of the vehicle and its size. They should be visible, therefore, till almost level with the vehicle carrying them, and, while having their maximum intensity in the ahead direction, should not give anything in the nature of a beam. An intensity of half a candle-power is clearly visible at one mile in ordinary weather, and since the range required is a matter of hundreds of yards only, it is difficult to assign any reason for the quite high-powered beams given by many types of sidelight at present. No one drives on their sidelights, and accordingly no one troubles to set them, so that on old cars they may be found pointing anywhere. In some instances I myself have found the sidelights of approaching cars quite as dazzling as their headlights. In my opinion, the custom of making sidelights miniature headlights should be abandoned. All that is necessary is a very small lamp with a frosted, and possibly domed, front glass. Polished reflectors certainly should not be used, least of all parabolic ones.

(2) *Glare and Methods of Overcoming It.*

It is well known that the presence in the field of vision of very bright objects reduces the ability of the observer to see, causes ocular discomfort, and distracts his attention. All those effects are grouped under the word "glare," but for the purposes of this paper, the first effect is by far the most important, and in the following we will use the word glare as meaning simply the reduction in the ability to see.

Since the luminosity of the background under the worst conditions, i.e., those of the country road, is zero, we can only reduce the excessive contrast between the brightness of the headlight and that of the background by reducing the candle-power of the headlight in the direction from which it is viewed. When the background is entirely dark it is a matter of experience that the ability to see is reduced even when the candle-power is no more than that of the filament direct. On a dark country road almost any light is glaring, and it would appear that glare vanishes completely only when the candle-power is reduced to zero. When the background is not dark the intensity can be considerable without causing sensible interference.

There are many devices on the market which reduce the glare by cutting down the intensity of the beam. They all act by diffusing the beam more or less, and in general slightly reduce the maximum glare by reducing the beam candle-power to a fraction of its previous value, and increase considerably the solid angle in which glare is experienced. The remedy is considered by many to be worse than the disease. A plain parabolic headlight, well-focussed, and accurately made, may blind the approaching driver as long as he is in the angle of the beam, but since this is small, he is likely to escape it when within, say, 100 ft. of the approaching car.

Still other devices change the colour of the beam. Any reduction in glare obtained in this way is due mainly to the reduction in intensity involved in the change of colour, and from the point of view of avoiding glare, the method is equivalent to reducing the efficiency of the bulb.

The only successful method, and the one which is coming into general use, is that of suppressing the light at angles above, say, 4 ft. from the ground. This may be done permanently, or only when meeting another car. Permanent suppression of the upward light has many disadvantages. Much of the pleasure and sense of security in night driving comes from bringing into view the overhanging foliage and other high objects along the road. In addition, a lamp with no light above the horizontal has a varying range of throw on account of the varying acclivities of the road, and ordinarily shows up vehicles and other objects by their lower extremities only. Consequently the method of using a "passing beam," i.e., suppressing the upward light when approaching another car, is the one generally adopted, and is the only method which will be discussed in detail in this paper.

There are three different types of arrangement in use, by which the upward light may be temporarily suppressed when meeting another vehicle:—

(1) Tilting both beams downwards through an angle equal to at least half the beam divergence, or tilting one beam and switching the other.

(2) The two-filament, three-contact lamp. (*a*) Filaments arranged one vertically above the other, the current being switched over from the lower to the upper filament when passing. (*b*) Filaments arranged one axially in advance of the other. The filament providing the passing beam is usually the one in advance of the focus, and, if so, is shielded on the lower side.

(3) Using one headlamp to give a spread beam with its top horizontal or slightly below, and the other headlamp to give a concentrated beam with its axis horizontal. The former is left on continuously, while the latter is switched off when meeting another vehicle.

The first method is satisfactory from the point of view of the oncoming driver, but tends to dazzle the user through excessive illumination directly before the car, and leaves everything to the right of the car in complete darkness. The necessity for moving parts introduces a certain amount of complication and unreliability, and the method, both in results and ease of operation, is considered to be inferior to either of the other two.

Method (2A) is often used on American cars. The filaments are almost invariably V-type, used with long-focus reflectors and spreading prisms. With well-focussed and accurately made reflectors, a small amount of dip is obtained, and if the lamps are carefully set this may be just sufficient to remove most of the upward light. In practice the method is rather uncertain, owing to the very limited amount of dip, and for this reason is considered to be inferior to (2B).

Method (2B) is used extensively in Germany, and is an effective solution of the problem, if properly adjusted. In the anti-dazzle position the whole top half of the beam is cut off, the divergence being at the same time substantially increased. In order to provide adequate side illumination in the ordinary driving position, and also to eliminate black spots, the device is usually used with spreading prisms, and this may result in too much spread when dipped, with corresponding reduction in intensity. By

carefully designing the prisms a reasonable compromise can be arrived at, and a distribution obtained which is about as good as given by Method 3. If prisms are not used, the method is suitable for fast driving on straight roads, but compares unfavourably with Method 3 on narrow or winding roads. Its chief disadvantage is, however, the necessity for special bulbs.

Method 3, properly designed and set, gives a result which is about as good as (2B), and has the advantage (to the user) of not requiring special lamps. At present the passing beam is usually obtained by means of a V-shaped filament in a fairly long-focus reflector, spreading of the beam being effected by vertical prisms moulded on the front glass. There is some advantage in distribution in having the source slightly out of focus in a vertically upward direction, but this is not usually done. The other headlamp usually has the same source and reflecting system, the prisms being omitted. The system is very good to drive by both on straight and on narrow, winding roads. A bright line is thrown across the road in front of the car, and this is very useful when partially dazzled by approaching headlights. Its chief disadvantage as a general solution is that it is not foolproof. A slightly better driving light is obtained by turning the spread beam upwards; this causes glare, and by removing the bright line makes the device in reality less useful to the user.

In my opinion, Method 3, properly used, is the best solution of the three, as it gives a safer driving light than 2B. Human nature, however, being what it is, I am inclined to think that Method 2B, being almost foolproof, is to be preferred as a general solution. In Section 3 of this paper I will endeavour to develop a system which, while being more foolproof than Method 3, will also give a better driving light.

(3) *Investigation of Ideal System of Illumination.*

There are always two steps involved in the solution of any problem. The first is to analyse the requirements and determine the form of the ideal solution. The second step is to find the simplest method of approximating to that solution. To begin by assuming that the reflector must be parabolic, and then to work out in detail the divergence and distributions produced by a lot of different sources, in and out of focus, is, in my view, to attack the problem at the wrong end. A perusal of many of the standard works on the subject gives one the impression that the number of sources and focussing positions treated is limited only by the writer's knowledge of mathematics. I will therefore try in what follows to treat the subject from first principles, and see to what conclusions this will lead.

There are two fundamental requirements:—

(1) A sufficient width of the road surface should be illuminated under all conditions to enable the driver to keep on the road and to avoid other users.

(2) The light required to meet requirement (1) should not interfere with the vision of the oncoming driver, and any additional illumination introduced for the convenience of the driver should be suppressed on meeting another vehicle, if there is any danger of this additional illumination causing glare.

It is suggested that both requirements would be met by using one headlight to illuminate, say, 10 ft. on either side of the car, and nothing else, for, say, a distance of 100 ft. ahead, while the other lamp illuminated the sides and the more distant parts of the road. The former would be the passing beam, and would be kept on continuously, while the latter would be switched off when meeting another car.

We will consider first an ideal, level road, w feet wide, bounded on each side by a wall H feet high. One lamp will illuminate the road surface only, from a distance d in front of the car to a distance D in front. The other lamp will illuminate the walls, and as much of the distance as possible.

In order to determine the ideal shapes of beam for this purpose we will use the principle that the cross-section of beam required to illuminate any surface is similar to the perspective view of the surface seen from the position of the lamp.

Applying this principle to the case of the passing beam, and assuming the lamp situated in the middle of our ideal road at a height h above it, we find that the required shape of beam to illuminate this road from a distance d feet to infinity is an isoscles triangle with the sides sloping below the horizontal an an angle of $\tan^{-1}\frac{2h}{w}$. If the road is only to be illuminated from a distance d feet in front of the car to a distance D feet in front, then the top of the triangle is cut off, and the required beam is trapezoidal.

Fig 5A is a perspective view of this road as seen from the position of the lamp. OA and OB are the edges of the road, and AB is a line drawn across the road d feet from the lamp. Then OAB is the shape of the beam required to illuminate the road surface to infinity. OC and OD are the top edges of the walls, which require for their illumination a beam of the shape CAOBDO. As this shape of beam is impracticable, we may assume that both

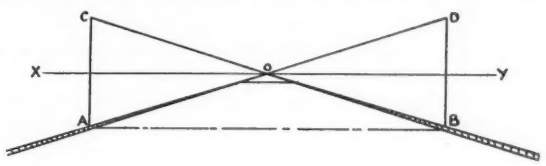


FIG. 5a.

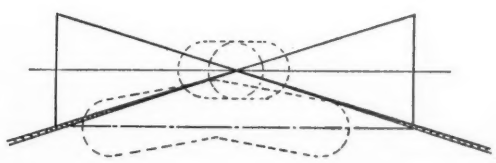


FIG. 5b.

lamps are to illuminate the road surface, in which case the shape of beam required from the second lamp is CABDO. If we draw the horizon line XY, then the angle XOA is $\tan^{-1}\frac{2h}{w}$, and the angle XOC is $\tan^{-1}\frac{2(H-h)}{w}$. The divergence in the vertical plane, i.e., the angular distance OE is $\tan^{-1}\frac{h}{d}$; the divergence in the horizontal plane, i.e., the angular distance AB is $2\tan^{-1}\frac{w}{2d}$. Assuming w = 20 ft., h = 3 ft., H = 6 ft., d = 30 ft., we get

$$\text{XOA} = \tan^{-1}\frac{6}{20} = 16.7^\circ$$

$$\text{AB subtends } 2\tan^{-1}\frac{20}{60} = 18.5^\circ \times 2 = 37^\circ$$

$$\text{XOC} = \tan^{-1}\frac{6}{20} = 16.7^\circ$$

$$\text{OE subtends } \tan^{-1}\frac{3}{30} = 5.8^\circ$$

As regards intensity distribution, it is clear that

the intensity should be infinite at the point O, and very small in the neighbourhood of the lines AB, CA and DB. It is not worth while going much further into the matter, as it is impossible in practice to control the distribution except within wide limits.

The above analysis applies only to a level road. Gradients of 1 in 20 are, however, quite common, with here and there gradients of the order of 1 in 5. A beam of the shape CABDO, if used on a hilly road, would have a widely varying range of throw, due to the varying curvatures in road profile, e.g., on a concavity, the edge of the beam would come in towards the driver. Now a gradient of 1 in 20 is about 3°, so to prevent this effect on ordinary roads, the top of the beam must be at least 3° above the horizontal. That is, if the beam has a vertical divergence of 6°, the axis of the reflector will be horizontal.

The necessity for having at least 3° of upward light considerably modifies the ideal shape and distribution of the driving beam. There is not now much to be gained by using a beam with the sides sloping upwards. I propose, therefore, to use a simple oblong beam with a bright centre, as shown dotted in Fig. 5B. It appears desirable to have the point of greatest intensity at O, but the best distribution is very debatable, seeing that in extreme cases this beam may be all in the air or all on the ground. This type of beam has the advantage of being very easy to produce in practice.

Fig. 5B also shows the practical form of the passing beam. It has the shape of an inverted V, and has its maximum intensity as near as possible to the apex of the V. It is considered advisable to have the top of the beam slightly below the horizontal, and for the beam itself to be pointed slightly to the left, depending on the amount by which the top of the beam is tilted down, say by 2° to 3° to the left when the top is 1° below the horizontal. If this is done, the downward slope of the sides should be less than $\tan^{-1}\frac{2h}{w}$, a reasonable figure being, in my opinion, about 10°. By considering the field of vision of the driver, it will be seen that the inverted V-shape is in itself advantageous, especially in the case of sports cars, where the seats are as low as possible. Fig. 6A is a sketch of a road as seen by

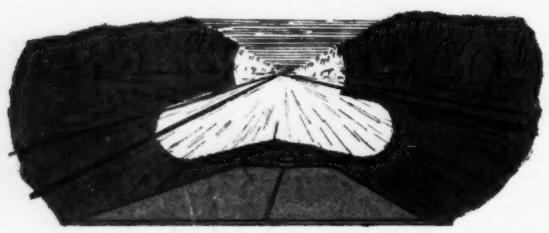


FIG. 6a.

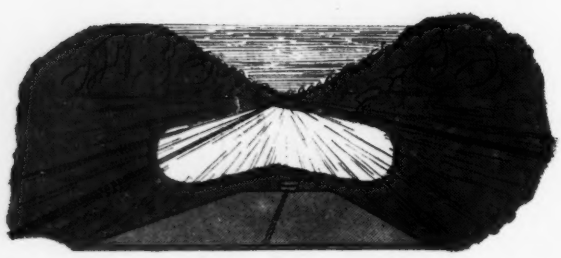


FIG. 6b.

the driver, with both beams in action, Fig 6B shows the same road illuminated by the passing beam only. A road 30 ft. wide from kerb to kerb has been taken as an example.

Now a system of illumination such as has just been developed would have a number of important advantages. The passing beam, by virtue of the downward slope of its sides, could never dazzle the oncoming driver if properly set, and is unlikely to dazzle him for long even if it is not. The best results, both driving and dipped, are obtained when both lamps are properly set, so that there is an incentive to the driver to maintain the settings correctly. The side illumination, being provided by the upward beam, is better than in Method 3 (described in Section 2), reducing considerably the danger of running down cyclists, and enabling corners to be turned with ease and safety. The absence of adequate side illumination has long been recognized as the chief disadvantage of the unmodified parabolic headlight from the driver's point of view, and is the chief reason for the use of spreading prisms and diffusing glasses. As has been explained previously, both these devices as used at present considerably increase the solid angle in which glare is experienced.

Coming now to the method of obtaining these two beams, the arrangement adopted must be simple and easy to manufacture, and should if possible resemble existing types of lamps. It follows that the reflector should be a surface of revolution, and that either the linear or the V-type source should be used. This necessarily means using spreading prisms to modify the shape of the beam, as any reflector which is a surface of revolution will give beams of approximately circular cross-section with either of these sources in any practicable positions.

Since the divergence required in the vertical plane is of the order of 6°, the use of a V-type source with the limbs fairly close together is almost imperative if an economical design is to be obtained. I therefore propose to use a V-type source, lying entirely within a rectangle of 0.17 ins. long by 0.12 in. wide, 0.17 in. being the distance from the apex of the V to the base. Such a source would give a divergence of the order of 6° used with a parabolic reflector of about 1¼-in. focal length.

It is proposed to use as a basis two circular beams of about 6° divergence, one arranged with its top about 1° below the horizontal and pointed about 2° to the left, and the other with its top about 3° above the horizontal and pointed dead ahead. Where spreading prisms are used, it is often found desirable to use a reflector giving a beam brighter at the edges than is obtained from a parabolic reflector used with linear or V-type sources. In the case of the passing beam this is particularly desirable, as the most distant parts of the road are illuminated by the top edge of the beam. It should, of course, be appreciated that the contour of the reflector is closely linked with the arrangement of the prisms. I propose to use a reflector in which the rays from the edge of the reflector go to the edge of the beam, instead of to the centre, as in the parabolic reflector, without, however, increasing the divergence. This both increases the intensity at the edge and simplifies the arrangement of the prisms. The equation to such a reflector, in polar co-ordinates, is:—

$$R = \frac{2a}{1 - \cos(\theta + \alpha)}$$

where α is half the maximum angle subtended by the filament at the reflecting surface, the outer end of the filament being at the origin. The beam given by this contour is as bright at the edge as is possible with a surface of revolution used with a linear source, or a V-type source as described above.

The reflector is shown in Fig. 7. The paths of two sets of rays are shown, from which it will be seen that the rays from the edge of the reflector cross the axis. It follows that the rays forming the

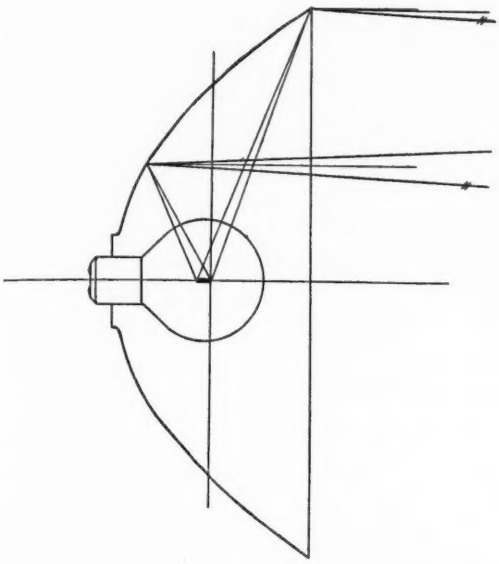


FIG. 7.

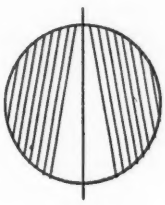


FIG. 8a.

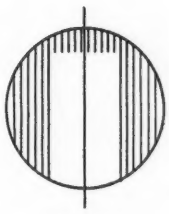


FIG. 8b.

top of the beam pass through the bottom of the front glass. It is intended to mount the lamp from the back, with the apex of the V-source at the origin.

Coming now to the prisms, it is well known that the direction of spread is perpendicular to the direction of the prisms. In the case of the passing beam two groups of one-way prisms are moulded on the front glass as shown in Fig. 8A. The prisms are arranged to run at an angle of about 10° to the vertical, the bottom of the glass being left blank in order not to spread the rays forming the top of the beam.

In the case of the driving beam the proposed prism arrangement is shown in Fig. 8B. The prisms are vertical, and only cover a portion of the front glass. The light passing through the plain portion goes to the centre and centre top portion of the beam. The exact arrangement of the prisms is not here a matter of great importance, and it is very probable that equally good results would be obtained using a parabolic reflector.

I am aware that the above explanation of how to attain the proposed solution is incomplete in many details. If, however, I have succeeded in outlining a new method of attack, which may lead to a more satisfactory solution of the headlight problem, I will have attained the chief object of this paper. More experimental work is required before the question of what is the best method of attaining the proposed solution can be definitely settled.

DISCUSSION

Dr. S. ENGLISH congratulated Mr. Calvert on his paper and on the manner in which he had presented it. The drawings were most illustrative. Those who designed headlights seemed prone to assume that the passing beam had to be kept entirely below the horizontal. Actually, however, all that had to be done was to keep the beam out of the eyes of the approaching driver. One evident drawback to beams with a sharp cut-off below the horizontal plane was that a slight tilt of the car owing to inequalities in the surface of the road was sufficient to raise the dividing line so that the full power of the beam was encountered by the eye of the driver of an on-coming vehicle. A beam at one moment might be out of the eye and the next moment in it, and it was even worse to have first of all glare and then dark than to have continuous glare. Instead of keeping the beam strictly below the horizontal, the driving beam or passing beam should, therefore, be confined to the near side of the road. If that could be done without the beam impinging on the other side of the road there could be a strong permanent driving light as well as a " non-glare " light, and that was surely the desired condition. When meeting another car the driver could extinguish the off-side light, keeping the near-side light in action.

Dr. S. English then proceeded to give a demonstration of a form of headlight which complied with the conditions outlined above. The lens was so designed as to give two distinct beams—one a confined beam directed straight up the near-side of the road; the other a diffused beam of much lower intensity and wider dispersion that served to illuminate the hedges, the grass edge and the kerb. The illumination could be carried upwards without causing glare to other drivers, the only possible danger of glare being when the car was going round a sharp left-hand corner; he thought, however, that there were fewer such corners than there were bumps in the road, so that the likelihood of glare arising was less than in the case of beams that were merely confined below the horizontal.

Mr. H. MARTIN gave a demonstration of a form of headlight utilizing a beam of the absolutely " flat cut-off " type. He had collaborated with his friend, Dr. English, who had suggested that one of the lamps should be switched off. With the system under consideration the whole of the right-hand side light could be cut off at any time. This headlight furnished a flat-top beam of rather a novel type, and he believed that he had nearly met Mr. Calvert's theoretical requirements. The only difference was that the cut-off was horizontal instead of three degrees above. In the ordinary way the beam was an absolutely horizontal, perfectly non-glare beam. In this case also there was a compound beam, comprising the main driving beam ahead and an auxiliary passing beam. The driving beam had rather an unusual spread, and it well covered the walls at the side of the theoretical road. The centre intensity was probably six degrees; there was an outer zone of twelve degrees and at the outside good illumination—twenty degrees. There was a sharply defined but fully illuminated flat upper boundary. The

auxiliary beam furnished local lighting with a wide spread giving high kerb illumination, which was a pronounced advantage in a fog.

The distant visibility was very good. Practical experience suggested that there was no drawback in confining the beam to the flat upper boundary; even in hilly country no appreciable disability resulted from the momentary foreshortening of the beam at the bottom of an incline. Furthermore, he did not think that safety or ease in driving necessitated a rising beam for the distant visibility of overhead trees, however agreeable it might be to see them. It was, however, contemplated that an emergency means of elevating the beam by 3° or so might be furnished, in order to meet the special needs of very hilly country or a driver's occasional desire for an elevated view ahead.

Whilst, from his own experience, he did not agree with Mr. Calvert regarding the disabilities of such a flat-topped beam as he had described, he was in accord with much that he had said regarding certain rather absurd ideas current in headlight practice—such as the conception that glare could be avoided merely by dimming the beam by coloration, diffusion or other means.

Mr. T. J. Sack hoped that it would not be thought inappropriate if he gave a somewhat elementary demonstration of a manner in which a parabolic reflector worked. The parabola was in one plane, and the actual lines coming off from one part of the reflector could be seen. One got approximately parallel rays. When the source was placed in front of the focal point the rays could be seen crossing over, and similarly behind the focal point. After tracing the course of the rays, Mr. Slack explained the principle of another form of headlight embodying what he preferred to call a temporary anti-dazzle device, as contrasted with the type of lamp that Mr. Martin had just shown, which was a permanent anti-dazzle device. The method, which was applied in the Graves type of lamp, furnished a cut-off approximating more nearly, perhaps, to the theoretical requirements outlined by Mr. Calvert. Mr. Sack then gave an interesting demonstration, by the aid of a small miniature incandescent lamp and a section of parabolic mirror.

Major Graves expressed his interest in Mr. Calvert's paper, though there were certain comments with which he could not agree. Mr. Calvert had rather tilted against the work of leading manufacturers of headlights, and he (Major Graves) thought that Mr. Calvert did not fully appreciate the conditions under which their work was done. Their headlights were the result of long-continued research and embodied scientific principles; yet the designs might nevertheless be affected by outside considerations (political and otherwise) which made it impossible to adhere to ideal requirements. In this research work both makers of headlights and electric lamp manufacturers were concerned. It covered many different subjects, such as filament formations and positions, the surfaces, curvatures and properties of concave reflectors, the use of prism combinations and other means of diverging, diffusing or scattering beams, etc. Their products were not always the best they could furnish, but were more frequently the result of compromise or affected by such considerations as compliance with codes or regulations, competitive price cutting or the whims of their customers (who, it should be remembered, were the car manufacturers and not the purchasers of the cars!).

Major Graves remarked that, apart from his own experimental work, he had seen experiments conducted away from the "routine path" of the paraboloidal reflector with elliptical or compound curvatures, and all tested with various forms of filaments, including the "axial line," "bow," "V," and other types. He had seen beams of many shapes and sizes. If the particular beam preferred by Mr. Calvert had not been selected, this was not necessarily due to ignorance on the part of manufacturers, but rather pointed to a difference of opinion as to requirements. Mr. Calvert seemed to criticize specifically one of the oldest and best-known of headlights. He did not know how far Mr. Calvert had tested this particular type, but his own experience was different. This headlight was, in fact, designed to meet the requirements in regard to range, width of beam and cleanness of field of light of leading manufacturers of cars, and had more than satisfied all these requirements.

Otherwise he found little to criticize in Mr. Calvert's paper, though he could not endorse his admiration for a 6-in. projector as "a very efficient form of apparatus compared with most optical devices." The "V" filament, although better than the "axial line," was not so satisfactory as the "bow" type, horizontally disposed and perpendicular to the axis. But high voltages and other manufacturing considerations had resulted in the present vogue for the "V" type. As a motorist with a moderately fast car, he would not like to drive either behind Mr. Calvert's combination nor against it; in the former case, because he always felt uncomfortable on a long night-drive if his beams were not symmetrical, and in the latter case because he always found that a most disconcerting thing on the road was to meet another car which "winked one eye." From a manufacturer's standpoint the chief difficulty —apart from the annoyance caused to car manufacturers who disliked having to change their blueprints and wiring operations—lies in the fact that the mass production of two different types of headlamps is uneconomical. Finally, in deciding the ideal form of headlight, there is always the international aspect to be considered.

Mr. G. H. Wilson expressed his interest in the paper, and showed a number of slides illustrating principles in design. He himself had always used with the parabola the method suggested by Ryde in 1928. This was not restricted to the linear filament, but could be used with any shape.

He did not accept Mr. Calvert's wholesale criticism of diffusing glasses, which did not necessarily have the effect of obliterating all distinctive features in a beam. With the usual type of lightly diffusing glass the effect was to increase the size of the image, there being a slight increase of divergence all round the image. In the centre of the beam the increase would have more effect on the intensity because the image shown was much smaller, but the actual total divergence of beam would not be very much affected. Mr. Wilson referred to one curve giving a beam-intensity of 70,000 candles. This was for a lamp with a reflector of clear glass, whilst a second curve was for a standard type of diffusing glass, and a third curve for the shadow-edged. When the beams were actually projected on a screen by means of the headlamp the effect on the edge was very slight. A headlamp of standard type with lightly diffusing glass added to it was probably of more practical value than one without it, and the total divergence was not very much increased.

He did, however, agree with Mr. Calvert with regard to the avoidance of unnecessary brightness of side lights. He also thought that the indication of a side light should be visible when a car was seen broadside on, so that cars approaching at right angles could see it. Further, the height at which side lights were mounted should be considered. In some cases they were at a height of 8 ft., and on that account were very difficult to see.

The suggestion of a new form of headlight was, he thought, certainly worthy of trial. It would be interesting to hear the opinions of people who had driven behind such a headlight.

Mr. L. GRIFFITHS stated that he spoke not as an illuminating engineer but a motorist. In the first place, Mr. Calvert had raised the point of the ideal form of illumination. One would imagine that the ideal form would be an intense central ray with lesser intensity spreading out to the sides. They had been told that steps had been taken, by means of lenses, to extend the side illumination, and from the standpoint of the motorist that was essential. Mr. Calvert had said that the method of projecting the light below the horizontal had many disadvantages. The only disadvantages that he (the speaker) could see were the two that had been mentioned. As for foliage, it was virtually non-existent in present main highways. One must necessarily stress the importance of uniformity of illumination over the whole area of vision. Sometimes one met intensely bright patches, and this was apt to lead to eye-fatigue. The method of illumination suggested by the author was a good attempt to solve the problem, but he felt that a more satisfactory solution would be one in which there was permanent illumination of the road below the horizontal—for which any legislation on the subject should provide.

Colonel J. A. A. PICKARD remarked that, having regard to what had been said, it seemed that two things were required: the first was a perfectly straight road, which one did not get, and the second was a perfectly level road, which also one did not get! No mention had been made of the practice of connecting up the headlights with the steering gear so that the direction of the beam was changed with the direction of the steering. That was a great advantage in turning corners—diminishing dazzle. Why did the regulations only permit the limit of swivel to be to the angle to which the wheels turned?

Mr. J. A. TRITTON, speaking from practical experience, suggested that a compromise between the two arrangements that had been mentioned would be very satisfactory. He had driven with the lamps arranged so that when the beam was dipped the light was cut off at an angle of 35° to 45° with the horizon. The effect was to give extra illumination on one side of the road, and also to put into shadow a slice of the road on which an on-coming car was about to travel.

The CHAIRMAN agreed that diagrams were often drawn on the assumption of straight roads. Trouble arose when rapidly manœuvring at speed, or turning corners. A beam that would give absolute security on the left-hand side or when approaching a corner was a great desideratum. In 1906 he experimented to avoid glare, and with horizontal beams and horizontal cut-offs eliminated the upper right-hand part, but both devices gave rise to criticism. What had struck him was the difficulty of ensuring that lamps were properly adjusted. A minute amount of movement was sufficient to throw them right out of adjustment. Even the loading of a car would do so. This problem had yet to be solved for the ordinary motorist, and presented difficulties even to people who had had scientific training.

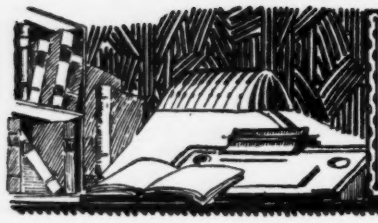
Mr. CALVERT, in reply, expressed his appreciation at the reception given to the paper. There had been much in the discussion and in the demonstrations and illustrations that was quite interesting. He considered, however, that the prismatic arrangement shown by Dr. English gave results which were less satisfactory than those given by the ordinary dip-and-switch arrangement. Dr. English had mentioned one possible disadvantage of his method, that it might give rise to glare when one was turning a sharp left-hand corner. There were two other drawbacks that occurred to him. The first was that when turning a right-hand corner one would be driving into a region of complete darkness. Better vision would be obtained in such a case by switching the headlamps off, as the strong illumination on the left side of the road would reduce the ability of the driver to see into the dark region into which he was driving. In other words, such lamps might be a hindrance rather than a help, when turning right. The second disadvantage was that glare was apt to occur whenever the car was pointed outwards from the near-side kerb. Dr. English had remarked that momentary glare was worse than continuous glare, but he (Mr. Calvert) doubted this. A flash of one-tenth of a second had an apparent intensity of only one-third of its actual photometric intensity.* Surely, even temporary relief assisted the driver to see where he was on the road, and the obstructions, if any.

With regard to Mr. Martin's arrangement, he thought the divergence of the triangular beam was too large, and its intensity too low. Also, the method of producing the two beams appeared to be rather complicated.

With regard to lamps following the steering, he had not been officially informed in regard to the explanation of the restrictions, but he understood that the objection was that this movement was liable to confuse other users of the road. Furthermore, the device was not very easy to arrange, and he had never seen it done. He thought that if care was taken with the ordinary type of headlight the requirements could be met with permanently set headlamps. In regard to difficulties involved at corners it should be remembered that one could not see round a corner, even in the daytime! The driving beam that he had shown had a sideways divergence of about 15°, and was so arranged because of twisting roads. It was quite true, as several speakers had remarked, that in general roads were not level, and he had suggested 3° (1 in 20) of upward light in consequence. Major Graves had disagreed with him in certain comments which he had made, both on the products of the manufacturers and on the work of others, and had urged that such firms worked under certain restrictions, political, international and merely whimsical. He did not think he had made any unreasonable criticisms, and these were concerned with the technical design of the headlight, not with its performance, and should therefore be rebutted on technical grounds. A disinterested outsider naturally could not be aware of the research work conducted by manufacturers unless particulars were published. He agreed with Mr. Wilson that diffusing glasses improved the driving qualities of the light, and that if the increase in divergence was small the resultant increase in glare was not dangerous. The trouble, however, was that most of them did increase the glare considerably. The increase in divergence shown in Mr. Wilson's first slide was comparable with the less diffusing of the two glasses mentioned in the paper. He thought that most people did not like driving with a permanently dipped beam, mainly for the reasons given in the paper.

The CHAIRMAN, in moving a vote of thanks to Mr. Calvert for his paper, remarked that it had led to an interesting discussion, and had evoked some criticism. This, however, was all to the good. If there could not be criticism when necessary, discussions would be rather futile. It was a great advantage every year or two to have such subjects brought up and to observe the progress of opinion.

* See paper, "The Application of the Blondel-Rey Law," by Jean Rey, 1929.



REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

"SEEING: A PARTNERSHIP BETWEEN LIGHTING AND VISION." (*Balliere Tindall & Cox, London*, 1931; *pp.* 241+26; *22s. 6d. net*).

The work includes the subject matter of a number of research papers published by the authors during the last few years. These have been merely steps in an organized research which is now presented in completed form. In choosing the title "Seeing," the authors argue that as light is essential to seeing and has become a controllable factor in human life, it has assumed a rôle of equivalent importance with that of vision itself, and they describe this partnership as "seeing." Regarded as a new science, it is suggested that there may emerge from it "seeing specialists."

The researches presented have been long, painstaking and laborious, and they carry the conviction of accuracy in a subject where accuracy is extremely difficult to attain. The measurement of visibility involves four main variables, viz., size, contrast, brightness and the time taken or allowed for seeing the object, i.e., "time of exposure." These are presented in all of their several relationships, always at the point of threshold visibility, in tables and graphs remarkable for their clarity and for skill in the selection of data.

The position still remains that the relationship between threshold and working values has not been scientifically or experimentally determined, because accurate measurements can be made only at the threshold. Therefore such factors as are necessary to translate the one into the other must be chosen arbitrarily. These factors, on which little guidance can be given, may be of the order of 100. In some cases, however, threshold is of direct interest, as, for example, where the authors, in a chapter on "Glare," ascertain the threshold of ocular discomfort. As another example, looking for flaws in a piece of metal involves directly the threshold of visibility. In other cases, as in a chapter on "Precision and Accuracy," the treatment is free of the threshold question.

The authors condemn the 1930 Code of Lighting Factories, etc., and advance a new code based on sorting the lighting field out into ten classes representing equal steps of foot-candle effectiveness. They range from 0.5 foot-candle to 500 foot-candles in a more or less geometrical progression.

There are many interesting passages: "Light is a magnifier of details. In a certain case an equal effect upon threshold visibility is obtained by increasing the brightness from 2.6 to 5.8 millilamberts or by increasing the size of the object by 10 per cent. In view of the differences in paper and printing, the illumination on the pages of a telephone directory should be three times that on those of a high-grade book. The average fixational pause of the eyes (as in reading a sign from a moving car or reading a line of type) is 0.15 second. (This is an instance of the importance of "time of exposure.") The most effective intensity of illumination for many serious visual tasks is between 100 and 2,000 foot-candles. A safe upper limit for the ratio of localized to general lighting is ten to one.

The book is wide in its scope. Sound philosophy is there as well as science. Save for colour, which is omitted, there is no phase of, or sidelight on, the problems of the lighting man in their broadest aspect of lighting for better seeing that is not dealt with in a book, one of whose objects is to lift lighting practice out of the bonds that tradition and mistaken economy have laid upon it. For its controversial aspects, as well as its scientific data and suggestive lines of thought, it should be valued by every lighting man interested to delve below the surface for constructive material. In its text-book form it will rank as a classic. A supplement, occupying 26 pages, contains a full explanation of the author's Demonstration Visual Test, illustrated by a series of 17 discrimination charts.

"THE PRACTICAL ELECTRICIAN'S POCKET BOOK." (*Odham's Press Technical Book Department, London*, 1932; *pp.* 569+*lxvi; 2s.* 10*d., post free.*)

The 1932 edition of this familiar pocket book, which contains over 600 pages of condensed material, remains a remarkable bargain at the very moderate price of issue. Substantial revisions have again been made. The section on illumination, which occupies 22 pages, does not appear to have been materially altered, but the sections concerned with wiring installation and the I.E.E. rules have been the subject of special attention, and others (such as those on marine electricity, portable electric tools, electricity in the textile industry, electric heating, domestic appliances, tariffs and switchgear) have been also revised. In addition, two new sections on "Power and Power Factors" and on "Picture Telegraphy," have been added. The latter, by C. Volk, is believed to be the first of its kind to appear in an electrical pocket book.

"THE 'GAS JOURNAL' CALENDAR AND DIRECTORY." (*Walter King Ltd., London*, 1932; *pp.* 234+*xxxii.*)

The *Gas Journal* Calendar and Directory for 1932 fully maintains the standard set up a year ago, when it appeared in an enlarged and improved form, and constitutes a line of valuable information to gas engineers. Apart from the actual diary there are over 300 pages of matter. The almanack, general information and memoranda are useful, and the Directory, divided into five parts, is exceptionally complete. This contains the familiar record of gas undertakings in this country and abroad, and it includes in Part III one particularly useful feature, namely, a complete list of public lighting superintendents in the United Kingdom, arranged alphabetically according to towns or districts. In each case is mentioned the name of the officer who actually deals with public lighting.

"DAYLIGHT BY NIGHT; A RECORD OF SOME OF THE MODERN INSTALLATIONS OF GAS LIGHTING IN IMPORTANT THOROUGHFARES IN GREAT BRITAIN." (*Pp.* 73+*illustrations.*)

This book, compiled by the British Commercial Gas Association, was prepared on the occasion of the International Illumination Congress. The paper and printing are excellent, and the whole book constitutes an impressive record worthy of the occasion. The bold letterpress is executed throughout on matt paper, the corresponding illustration facing it being on interleaved art paper, so that the reader has the advantage of both forms. The photographs are in general excellent pieces of work, and there are in addition four coloured plates, reproduced from water-colour illustrations by William Monk, R.E., illustrating "The Entrance to the Courtyard of Buckingham Palace," "Whitehall," "Scarborough Bay," and "The Marine Parade, Brighton." All are pleasing pictures, giving an idea of the effect of artificial light. In the case of most of the streets illustrated particulars of the lighting equipment (and in some cases also foot-candle values) are given.

The Photo-electric Recording of Daylight

By L. H. McDERMOTT, A.R.C.S., D.I.C., B.Sc., and C. J. MacMANUS, B.Sc., of the Photometry Department, National Physical Laboratory

ABSTRACT.

This paper describes a photo-electric apparatus which has been constructed and put into operation at the National Physical Laboratory for the continuous measurement of daylight illumination. The method by which the records are calibrated is outlined and a number of examples of typical records is reproduced, together with a brief analysis of each with respect to the weather conditions and time of year.

Introduction.

WHEN the photo-electric effect was first established as a definite physical phenomenon its value as a means of measuring solar radiation was soon realised. As early as 1893, Elster and Geitel[1] employed a sphere of amalgamated zinc connected to an electrometer for measuring the degree to which the ultra-violet light in the sun's rays was transmitted by the earth's atmosphere. Later, when it became possible to produce photo-electric cells possessing an appreciable sensitivity in the visible spectrum, the use of such cells as instruments for solar radiation measurements became immeasurably greater. The first instance of daylight illumination being directly measured photo-electrically was when Elster and Geitel employed this method during a solar eclipse at Palma, Mallorca, in 1905[2]. Following this, the lunar eclipse in November, 1910,[3] and the solar eclipse in April, 1912,[4] both at Wolfenbüttel, were investigated in a similar manner. The advent of these new cells, which were of the potassium hydride type, and which possessed a much larger sensitivity than the earlier cells, made it possible to use a moving-coil galvanometer, and to observe actual deflections instead of measuring the drift of an electrometer needle, as in the case of the zinc sphere.

By 1922, biologists had begun to consider the applicability of the photo-electric cell to accurate quantitative measurements on the effect of daylight illumination on plant life. Shelford and Gail,[5] with marine biological aims in view, attempted with considerable success to measure with a photo-electric apparatus the illumination at various depths in the sea. Further work of this nature was undertaken by Poole,[6] and Atkins and Poole[7] have subsequently made considerable development of this subject.

In measuring daylight for the purpose of dealing with its effect upon vegetable, plant, animal or human life, it will be clear that isolated observations of instantaneous illumination are not of great significance, but that it is the time integral of the illumination spread over considerable periods which is of importance. It is true that for constant illumination this time integral can be obtained from a single observation, or for evenly varying illumination from a small number of observations at regular intervals. But daylight does not vary in a regular manner, as is shown by the fact that in the course of a minute, variations of 50 per cent., or even more, are the rule rather than the exception. Consequently a true idea of the amount of daylight throughout a day can be obtained only by a continuous record. This was first attempted by J. E. Ives[8] in 1925, when he recorded the total day illumination on a horizontal plane, using a photo-electric cell in combination with a recording potentiometer. A few years later, Koller,[9] using a special large cell, was able to operate a thread recorder with the current obtained by placing the cell at a window in his laboratory.

In the case of the records of Ives and Koller no attempt was made to separate the illumination due to direct sunlight from that due to diffuse reflection from the sky and clouds. It has, however, been found that in problems connected with the lighting of buildings, a knowledge of the values of the latter are of more assistance than the corresponding values of the total flux. Further, because of the uneven distribution of illumination throughout the sky, it has been found convenient to divide it into four sections, the north, south, east and west quadrants, and to make separate measurements of the illumination in each.

At the request of the Illumination Research Committee of the Department of Scientific and Industrial Research, the production of continuous records of daylight illumination, using a photo-electric apparatus, has been undertaken by the Laboratory. Records, each extending first over three days and later over five days, have been obtained almost without break during the past two and a half years. So far, all measurements have been restricted to the north octant of the sky. A brief account of the present photo-electric apparatus has recently been published.[10]

Apparatus.

For the purpose of description, the apparatus employed can best be divided into two main sections: (*a*) the screening device shown in Fig. 1, whereby

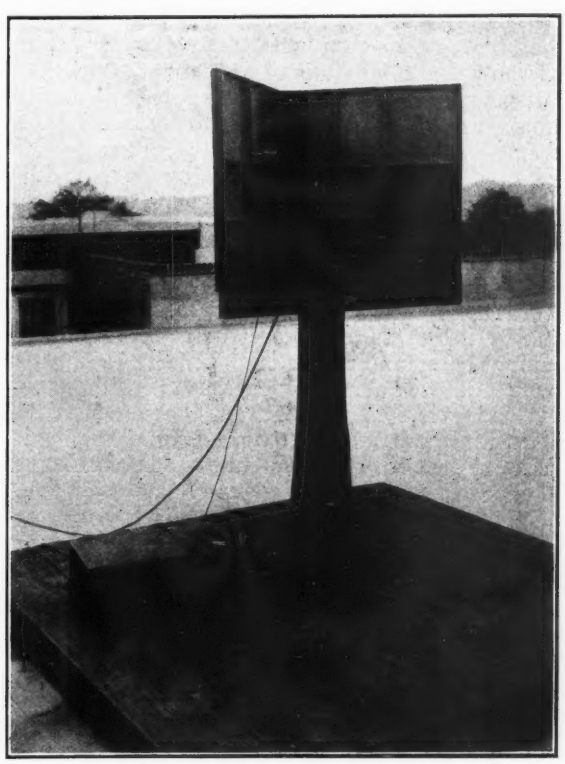


Fig. 1.—The Octant.

[1]Elster and Geitel, Ann.d.Phys., 48 (1893), 338.
[2]Elster and Geitel, Phys. Zeit., 13 (1912), 739.
[3]Elster and Geitel, Phys. Zeit., 11 (1910), 1212.
[4]Elster and Geitel, Phys. Zeit., 13 (1912), 852.
[5]Shelford, V. E., and Gail, F. W., Publications, Puget Sound Biol. Sta., III, 65 (1922), 141.
[6]Poole, H. H., Sci. Proc. Roy. Dublin Soc., 18 (1925), 99.
[7]Poole, H. H., and Atkins, W. R. G., Jour. Marine Biol. Assoc. 14 (1926), 177; 15 (1928), 455; 16 (1929), 297. Sci. Proc. Roy. Dublin Soc., 18 (1926), 277; 19 (1929), 173 and 295. *Biological Rev.*, 5 (1930), 91. *Nature*, 125 (1930), 305.
[8]Ives, J. E., Trans. Ill. Eng. Soc., New York, 20 (1925), 498.
[9]Koller, L. R., *Gen. Elec. Rev.*, 31 (1928), 85.
[10]Harrison, T. H., *Nature*, 125 (1930), 704.

the illumination falling on the photo-electric cell is restricted to that from the north quadrant of the sky (since the screens enclose an aperture equal to an octant of a sphere it will be convenient to refer to it as the "octant") and (*b*) the recording mechanism.

(*a*) The octant, which is made of cast iron, is composed of four separate components—a heavy stand supporting a triangular-shaped base and two screens. The base, bolted to the top of the stand, contains in its right-angled corner a square box, in which the photo-electric cell is housed. The screens, bolted together before being placed into position, rest upon the base to which they are fixed by a row of screws. Each screen is about 2 ft. square, and is provided with horizontally and vertically placed slats, so spaced that the light reflected from the screens into the cell is a minimum. The octant with its photo-electric cell is placed on the flat roof of a high building, so that the sky is unobstructed by neighbouring trees and buildings. The stand is firmly fixed to a wooden platform to prevent the whole being blown over in high winds.

The photo-electric cell is mounted in a bakelite holder, and placed into position in the centre of the cell box, and the leads to it enter through two holes in the bottom. These are sealed and the holder is kept from moving by pouring in molten bitumen to a depth of several millimetres. A photo-electric cell of the potassium hydride neon-filled type, made in the Laboratory several years ago, is utilized in the apparatus and is operated at voltages varying between 12 volts in summer and about 100 volts in winter, a periodical change being necessary in order to make use of the full width of the recording paper. Because of the excessive sensitivity of the cell to the blue of the visible spectrum, it is covered with a yellow gelatin filter (Wratten K3), as it is found that this combination possesses a spectral sensitivity which approximates to that of the average human eye.

With the exception of a narrow flange on the outside, the top of the cell-box is machined to a depth of about 3 millimetres, thus permitting a sheet of glass to be used for covering the box without fear of breaking it by pressure from the screens. The cell-box is rendered water-tight by the application of several coats of a solution composed of collodion and canada balsam to the edges of the cover glass. Effective sealing here is essential, as any moisture condensed on the cell causes serious leakage and leads to fallacious results.

The box housing the energizing battery is also made of cast iron, and consists of a lid with a machined flange fitting tightly over a flat base provided with a rim to raise it off the ground. The leads enter through two holes in the base, bitumen again being used for sealing. Leakage currents between the leads to the recording instrument can only be eliminated by having the two at nearly the same potential, and this is effected by placing the battery-box as close to the octant as possible. Also, leakage to the walls of the building is reduced to a minimum by having the leads of heavy ignition cable.

It was found necessary in order to eliminate the effects of electric and magnetic disturbances within the building to earth the octant and battery-box with bare copper wire, which is afterwards wound round the leads to the galvanometer.

(*b*) The recording mechanism is housed in a small room near the top of the building, on the roof of which the octant is situated. Mounted on a brick pillar built up from the concrete floor is a wooden box containing a sensitive moving-coil galvanometer, to which the leads from the cell are directly connected, one terminal being earthed. A beam of light from an illuminated aperture, after being focussed by a lens, falls on the mirror of the galvanometer, and is reflected into a slit about $\frac{1}{8}$ in. in width and extending nearly across the side of the box. Placed against this side is a second wooden box provided with a slit which corresponds in position to the first slit. The side of the second box facing the slit is made detachable for the purpose of changing records, and when in position rests against small wooden fillets. The system of rollers which passes the records in front of the slit is mounted on a metal plate, which fits between two metal strips in the base of the box.

The sheets on which the records are obtained are of bromide paper, each 10 ft. in length and 15 ins. in width. One end of each sheet is first placed over a groove cut in a wooden roller, and is then held firmly by pressing a brass rod into the groove. A considerable amount of tension may be placed on the record when in a tangential position to the roller, but when in a radial position the end of the sheet is easily pulled out. This allows the apparatus to be left unattended when the record is nearing the end of its run. After winding the record on to this roller, the other end is passed over two guiding rollers, and is secured to the driving roller by being screwed under a sunken metal strip. Tension in the sheet is maintained by metal springs pressing against the first roller. When the roller system is in position, that part of the record in front of the guiding rollers is parallel to the side of the box and the light passing through the slit falls between them.

The driving motor, mounted on a separate brick pillar, is connected by a sliding collar to the driving roller through a reducing system of worms and cogs. These are of such a size that the reducing ratio is in the region of 260,000, and the speed of the motor is adjusted so that one revolution of the driving spindle is completed in about nine hours. Since the motor was driven from the main supply, it was thought advisable to employ a ball governor to maintain the speed approximately constant.

In order to calibrate the records with respect to time, a mark is made once each hour on the edge of the recording paper. This is effected by means of a flash-lamp bulb, which illuminates a small rectangular aperture in a screen placed at the extreme end of the long slit, on each completion of an electric circuit by the passing of the minute-hand of a clock through a mercury switch.

Calibration of the Records.

For the purposes of calibration the octant containing the photo-electric cell is installed close to another octant already in use for the visual measurement of daylight illumination. The latter is provided with a piece of ground pot opal, occupying a position corresponding to that of the photo-electric cell, and the illumination falling upon it from the north quadrant of the sky is measured by means of a portable photometer thrice daily, at 9 a.m., noon, and 3 p.m., G.M.T.

When the records are developed they are spread out on the lid of a specially constructed box, which serves the double purpose of table and storage box. In the regions of the records corresponding to the nights, the trace is straight, and for all such periods on the same record, approximately the same distance from the edge. Thus assuming that the night

illumination is insufficient to cause the galvanometer to register a deflection, the straight line including the trace for these periods may be taken as the line of zero illumination. This line and the other calibration lines are drawn by means of a drawing-pen attached to a specially constructed T-square by a small carriage capable of being clamped at any point on the long arm of the square. By this means long parallel lines can be drawn with ease. The hour lines are inserted by using the hourly calibration marks along the edge of the record.

For each time at which visual measurements are available, the height of the trace above the line of zero illumination is measured, and the mean height of a trace for 100 foot-candles is calculated. Since the records cover a period of five days, in general fifteen calibration readings are available; but owing to the rapid fluctuations of the illumination for certain types of weather, it is not always possible to place reliance on all these readings. However, as yet, each trace has always been found to provide an adequate number of accurate calibration values.

Discussion of Records.

During the period in which records have been obtained widely divergent types of weather have been experienced, and to illustrate the extent to which the variation, as well as the actual quantity, of daylight illumination is dependent upon the weather, a number of typical records is reproduced. The first shown, in Fig. 2, is illustrative of an

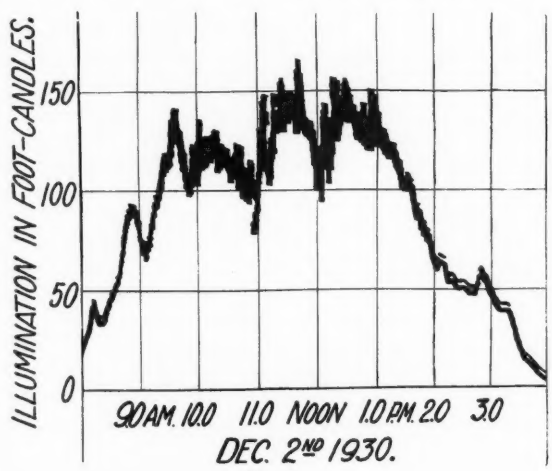


Fig. 2.

average winter's day, when the sky was overcast with heavy clouds. The figure of 79 foot-candles for the mean illumination throughout the day, when compared with the corresponding figure for an overcast summer's day (see Fig. 6) shows the fall in illumination caused by the much lower altitude of the sun. It may also be mentioned that on very misty or foggy days this figure has been found to be as low as 24 foot-candles. Fig. 3 shows the type

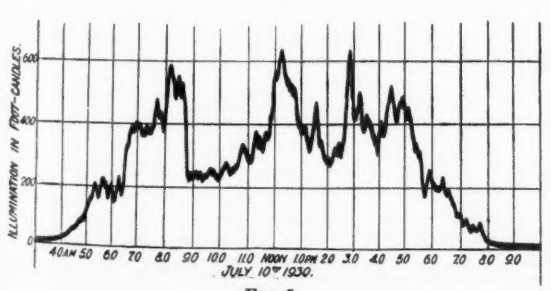


Fig. 3.

of curve produced by an average summer's day, when a blue sky was traversed by white clouds of varying sizes. The peaks in the curve indicate the passing of these white clouds, and demonstrate the large increase in illumination which was thereby produced. By joining the lowest points on the curve, an approximation to the illumination from the corresponding cloudless sky is obtained, thus showing that the additional daylight from a white cloud may be as much as twice that from the whole blue sky.

For a day on which the sky is entirely devoid of clouds the illumination is found to be remarkably steady, as is shown in Fig. 4; the crest in the curve

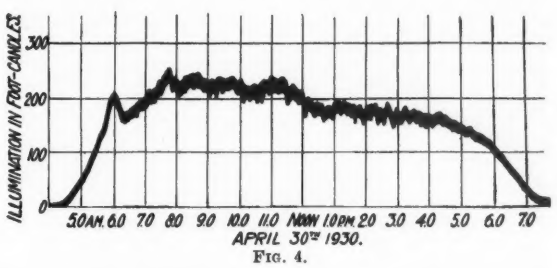


Fig. 4.

in the region of 6 a.m. seems to indicate the passing of a bank of white clouds. In Fig. 5, cloudless blue

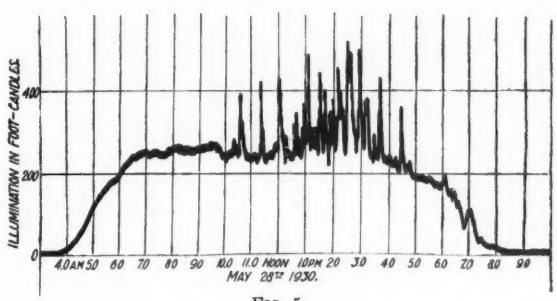


Fig. 5.

sky is indicated until about 10 a.m., after which at intervals of about half an hour solitary white clouds crossed the sky, thus accounting for the isolated peaks. A large number of curves of this type were obtained during the summer, the relative widths of the peaks depending on the size and speed of the cloud banks.

Conditions which can be described as "overcast and raining" are responsible for Fig. 6. The

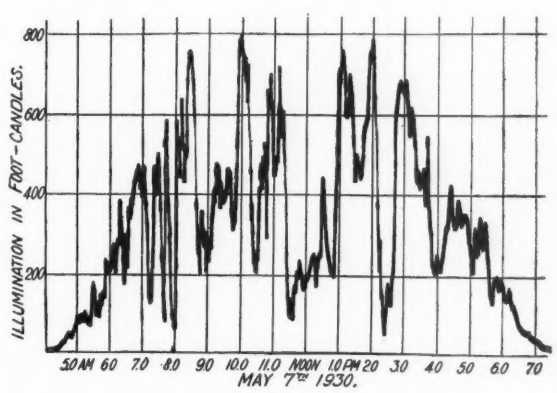


Fig. 6.

notable features of this record are the rapid fluctuations in the illumination due to the passing of heavy rain clouds, and the high maximum illumination of about 800 foot-candles attained several times during the day, due to exceptionally bright clouds.

Fig. 7 depicts the type of curve produced on a day which was mainly cloudy with small patches of blue sky, and is thus an approximate inverse of Fig. 5. The small decreases in illumination from time to time are due to these occasional openings, while the sudden rise at about 11 a.m. and the even

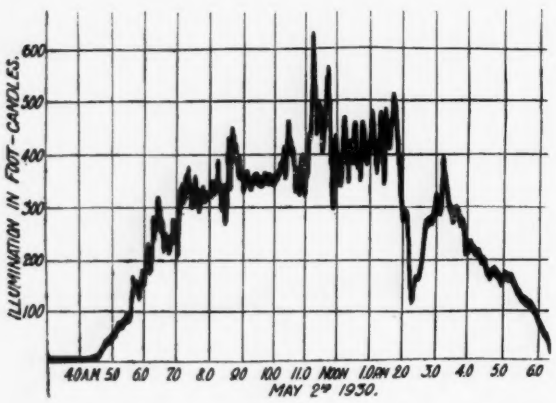


FIG. 7.

more sudden drop at 2 p.m. are due to the passing of exceptionally light and dark clouds respectively.

A thick morning haze with a background of variable clouds gave rise to Fig. 8. From the record,

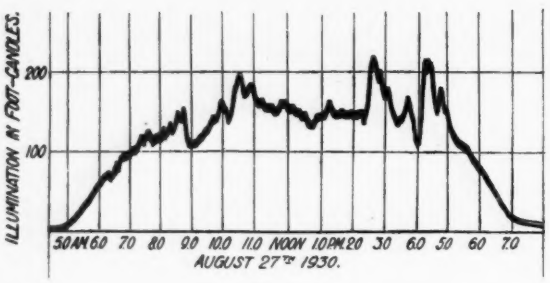


FIG. 8.

the haze seems to have been partially dispersed by about 9 a.m., after which the variations in the curve seems to be due both to the changes in the intensity of the haze and the moving clouds behind.

The last type of record given in Fig. 9 shows the curve obtained for a day which was entirely overcast

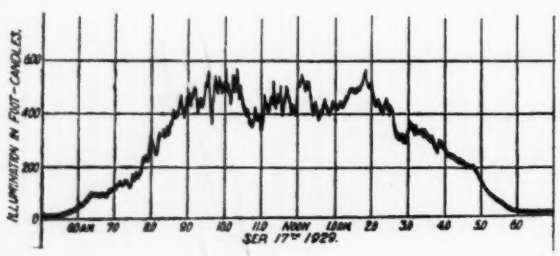


FIG. 9.

with clouds of varying intensity. A fairly even illumination was found to be experienced, the mean value being considerably in excess of that for a cloudless day.

For each of the records shown, the total foot-candle-hours and mean foot-candles have been determined, and, when placed opposite the type of weather producing them, illustrate the extent to which the illumination is dependent on the weather and on the time of the year.

TABLE I

Fig.	Date of Record	Type of weather	Total Illuminat'n ft.-candle-hrs.	Mean Illuminat'n ft.-candles
2	Dec. 2, 1930	Average winter's day	710	79
3	July 10, 1930	Average summer's day	4980	293
4	April 30, 1930	Cloudless blue sky	2440	163
5	May 28, 1930	Blue sky with detached clouds	3650	221
6	May 7, 1930	Overcast and raining	4800	320
7	May 2, 1930	Mainly cloudy with openings	3980	274
8	Aug. 27, 1930	Light cloudy sky with thick haze	1960	135
9	Sept. 17, 1929	Entirely overcast	3700	296

N.B.—These figures refer to the North Quadrant only.

In conclusion, the authors wish to thank Dr. J. W. T. Walsh and Dr. T. H. Harrison for assistance in the preparation of this paper, and also Mr. A. Turl for mechanical skill in the construction of the recording device.

Easements of Light

We have received a copy of a paper on the above subject, read by Mr. John Swarbrick before the Manchester and District Association of the Institution of Civil Engineers on November 12th. This contains an interesting survey of the history and regulations affecting access of daylight. The law of light is of great antiquity, being derived from the relics of Roman law retained in this country: a case so far back as A.D. 830 is recorded. The first effort to assess depreciation of illumination scientifically is ascribed to Professor Robert Kerr, an architect, about 1865. Plans depicting intensities of illumination were published in Paris by Henry Marechal in 1894, and members of the Illuminating Engineering Society do not need to be reminded of the pioneering efforts of Mr. A. P. Trotter and the original work subsequently done by Mr. P. J. Waldram in this field.

The method adopted by Mr. Swarbrick, and presented in Mr. A. C. Stevenson's paper before the International Illumination Congress last September, is based on the use of radial diagrams, and the author illustrates his Daylight Factor Theodolite, and the imposition of the angular g ill over the photographs obtained therewith, as a means of determining daylight factors in interiors. The author recalls the well-known case of Charles Semon & Co. Ltd. versus the Bradford Corporation (1922), which led to the adoption of a minimum daylight factor of 0.2 per cent. as a standard for business premises in towns, but higher values are approved in schools, for which a committee of the Illuminating Engineering Society has recently recommended 0.5 per cent. (almost 1 per cent. may be expected in new schools for which favourable sites can be secured).

The author also mentions the "Heliodon" apparatus, in which the sun can be represented by an ordinary electric lamp, and which has for its object the determination of the number of hours during which access of sunlight will be enjoyed provided the sky is not cloudy.

The Tenth Anniversary of the Illuminating Engineering Research Institute of Karlsruhe

By Dr.-ING. N. A. HALBERTSMA

THE Technical University of Karlsruhe (Baden) dates from 1825, being the first founded of the many technical universities which are now spread over Germany.

During the first century of its existence many well-known scientists have held chairs at Karlsruhe. Here Hertz has made his famous experiments on the transmission of electro-magnetic waves; Bunsen lectured on chemistry at Karlsruhe; and Engler, a pioneer of scientific gas-research, founded the Institute of Gas Technology.

In 1921 a Research Institute for Illuminating Engineering was added to the various laboratories of Karlsruhe. Professor Teichmüller for many years had already included lectures on illuminating engineering as a supplement to his course on electricity, but he foresaw the necessity of giving a full course for the training of illuminating engineering specialists. Professor Teichmüller therefore approached the electrical industry, and succeeded in arousing interest in his project and in obtaining the necessary funds.

This Illuminating Engineering Research Institute is intended to serve a double purpose, that of lighting research in the broadest sense, and that of providing experimental facilities for the training of specialized engineers. In the ten years which have elapsed since 1921 additional accommodation has been provided for the Institute, which now includes one lecture-theatre, twelve laboratory-rooms, three office-rooms, one workshop and various accessories. altogether occupying 5,000 sq. ft., as well as a permanent museum of lighting demonstrations, which contains an extensive collection of apparatus from the Gesolei-Exhibition in Düsseldorf (1926). At this exhibition of hygiene about 12,000 sq. ft. space was allotted to the subject "Light," and was equipped under the direction of Professor Teichmüller.

The work which has been done at this Institute, and the publications emanating from Professor Teichmüller and his assistants, illustrate the rapid development of illuminating engineering during the last ten years. At the beginning of this period Professor Teichmüller contributed to the foundations of the art by publishing a number of studies on the "Photometric Quantities and their Units." These studies showed the importance of making a clear distinction between three different kinds of "point-sources" which have often been mixed up. These studies also pointed out the fundamental importance of the brightness sensation of the human eye. Next came the construction of the spherical-angle projection model ("Lichtstromkugel"), which proved to be of great assistance in the calculation of average illumination on uncovered surfaces

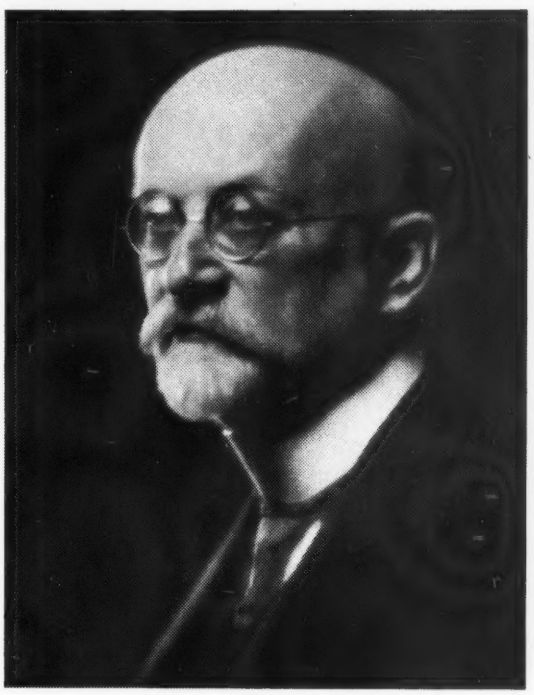


FIG. 1.—Professor Dr. J. Teichmüller.

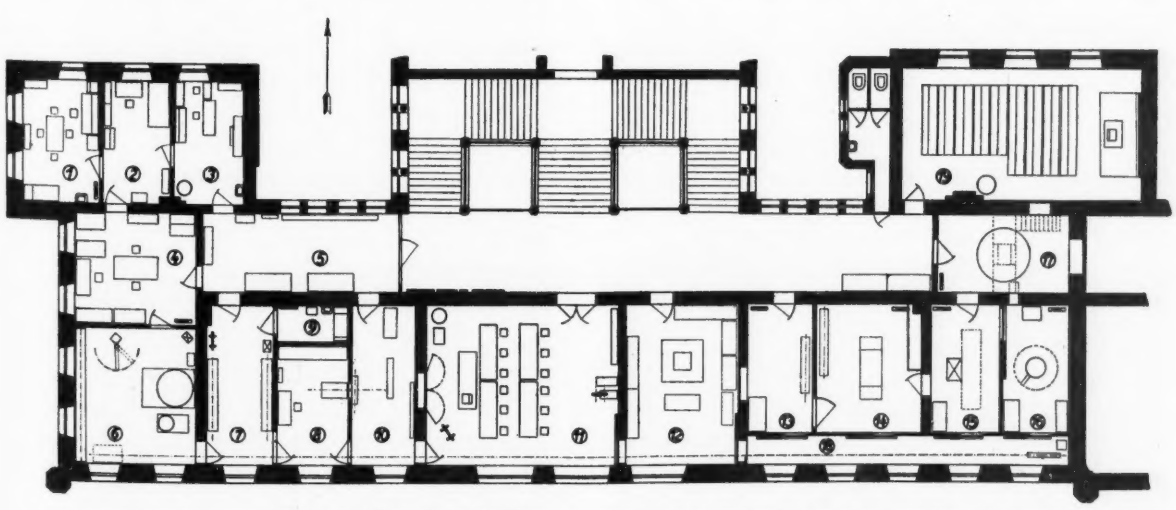


FIG. 2.—A Plan of the Building. Rooms (1) to (4) are devoted to administration. (1) is the office of the Director, (2) the Library, (3) the Secretary's Room, and (4) the Common Room for Assistants. Room 5, which is illustrated in Fig. 3, contains various linear distribution boards, racks for small accumulators used in the laboratories, etc. Rooms (6) to (11) have black walls and serve for photometry, except (9), which is a photographic dark-room. Rooms numbered from (12) onwards are the most recently equipped. Rooms (13) to (17) serve for research, (18) contains a photometric bench 44.4 m. long, and (19) forms the lecture theatre and demonstration room.

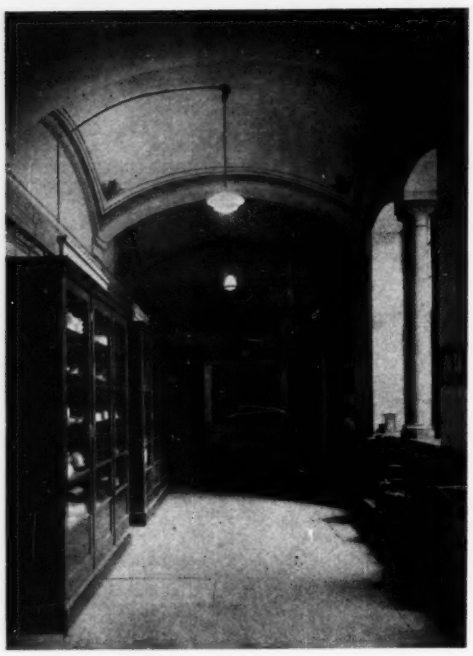


FIG 3.—Passage containing switchboards, distribution boards, racks for small accumulators, etc.

and in interiors. Investigations effected with the integrating spheres yielded valuable information on the interior coating and on the errors which can occur in the Ulbricht sphere.

From the very beginning of the Research Institute's work Professor Teichmüller turned his mind to the physiological phenomena underlying vision and the lighting art. He became conscious of the fact that there was apparently no branch of engineering in which physiology played such a predominant part, and he succeeded in obtaining the collaboration of some physiologists of reputation, amongst whom may be mentioned the late Professor von Kreis, of Freiburg University.

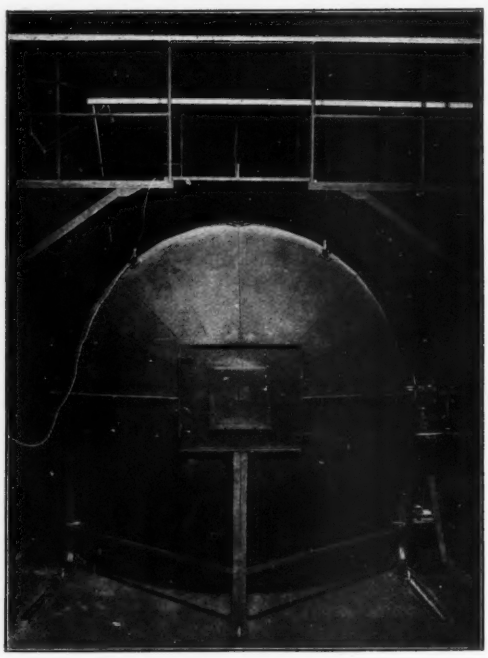


FIG. 4.—Large Integrating Sphere.

Dr.-Ing. R. G. Weigel, Professor Teichmüller's chief assistant, and lecturer on physiological optics, has published many papers on glare and on vision with coloured light.

In 1926, when preparing the special lighting demonstrations at the Düsseldorf Exhibition, Professor Teichmüller noticed certain new applications of light in interior and exterior decoration, designed by several progressive architects. He foresaw the ultimate possibilities of this development of the lighting art, which had obtained its first impulse by the Paris Exhibition of Decorative Arts in 1925, and in 1927 he published an analysis of these specimens which he called "light-architecture."

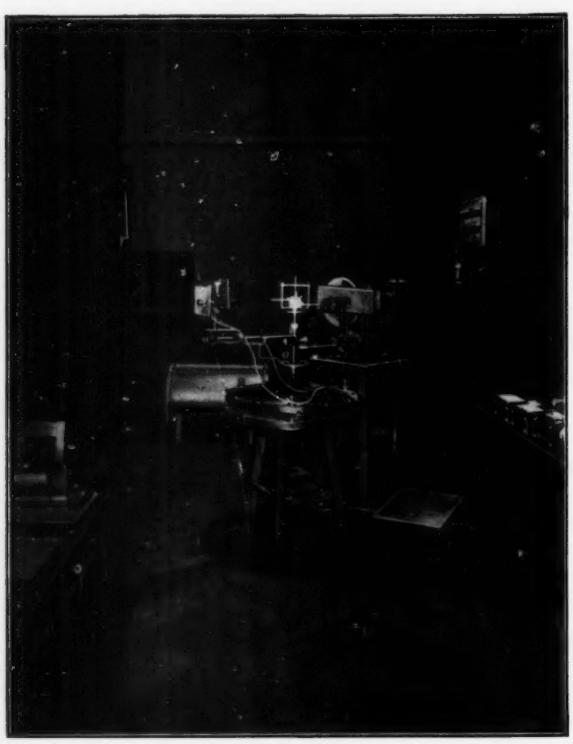


FIG. 5.—Laboratory devoted to measurements of reflection and transmission.

FIG. 6.—Photometer Room, containing rotating minor equipment (for obtaining polar curves of light distribution).

We have witnessed a rapid development of "lighting architecture" throughout the world. When, ultimately, light-architecture will be taught along systematic lines, this will be largely due to Professor Teichmüller's work, who is still devoting a good deal of his time to this most fascinating subject.

On November 28th, 1931, many of Professor Teichmüller's colleagues, students, and other good friends, as well as a number of illuminating engineers who have been trained at Karlsruhe, met at the occasion of the tenth anniversary of the Illuminating Engineering Research Institute. It was a celebration of a simple and dignified character.

Most of the information given above was derived from the address delivered by Professor Teichmüller on that occasion, and covering the ten years.

Two of the scientific collaborators of the Institute, Dr.-Ing. R. G. Weigel and Dipl.-Ing. O. Knoll, reported on research work of a recent date, which has not yet been published. Although space does not permit us to go into details, we are glad to reproduce some statements of Dr. Weigel which he made in his paper on "heterochromatic photometry." "Careful investigations at the Karlsruhe Illuminating Engineering Research Institute have proved that all three methods of heterochromatic photometry: flicker-photometry, the direct comparison of brightness photometry and the cascade method, which uses a large number of intermediate colour-steps, produce absolutely identical results if certain experimental precautions are observed. Any uncertainty about the accuracy of a spectral sensitivity curve of the eye, measured with one specified method only, e.g., flicker-photometry, will therefore disappear." These results, by the way, are very promising for the ultimate possibilities of the energetic method of reproducing a unit of light, as proposed by Professor Ornstein, of Utrecht, at the Cambridge meeting of the International Illumination Congress.

Dr. Weigel also reported on a very extensive series of measurements, which had been carried out at the Karlsruhe Institute for the German Illuminating Engineering Society and the German Society of Glass Technology. Dipl.-Ing. Knoll's work has been chiefly connected with colorimetric problems. He has investigated, among others, the changes of colour which are noticed with frozen meat, the fading of coloured papers under various sources of light, and the reflection coefficient of wallpaper with modern large-sized designs. A considerable amount of other research work in the various fields of illuminating engineering has been carried out at the Karlsruhe Institute, and its personnel has frequently been called upon as experts in many patent cases and other law cases, in which lighting played a part.

As to the value of the training at Karlsruhe, interesting conclusions could be derived from the life-story, as told on this occasion by four former students of Professor Teichmüller's, who since have taken up illuminating engineering as their profession. Mr. Hölscher started out as a consulting illuminating engineer. Collaborating with two architects, he became responsible for the design of the Titania Palast Cinema in Berlin, which has attracted a good deal of attention as the first large application of light-architecture in such a building.

FIG. 7.—A Glimpse of the Demonstration Hall: Exhibits illustrating shadow effects will be seen in the background.

The modern illumination of the Zoological Garden in Berlin is also due to Mr. Hölscher, who has since entered the Berlin Electric Supply Organization (Bewag), as chief illuminating engineer. Mr. Humbel had been for years with the Bronzewarenfabrik Tungi, in Switzerland, manufacturers of luminaires, when he entered the Karlsruhe Technical University. After finishing his course he returned to his firm as illuminating engineer, designing fixtures and luminaires. Mr. Ludwig Schneider has been for several years responsible for the management of the well-known "Osram-Lichthaus" in Berlin, and has been in charge of the technical lighting development work of the Osram Co. of Berlin. Amongst the large number of his publications on various lighting problems we would like to mention specially those which refer to the physiology of seeing. Mr. Marx, on leaving Karlsruhe, entered the employment of the Ufa-Film Company, in Berlin. He gradually rose to the rank of technical manager, and succeeded in introducing the 100 per cent. use of artificial light in the film studio. Having travelled all over the world, he ultimately settled down in Berlin as a consulting engineer for film studio lighting.

Time did not permit of other engineers telling their experience in the lighting field, but those present certainly caught interesting glimpses of the possibilities of the comparatively young profession of the illuminating engineer. In spite of the present economical crisis, which exerts its influence everywhere, the illuminating engineers who have been trained at Karlsruhe have found employment in various fields. Central stations want them for street lighting; municipal building authorities for the lighting of schools, infirmaries, offices; railway authorities for signal- and car-lighting; contracting firms and fixture manufacturers for their designing departments; architects for their studios, etc., etc.

Professor Teichmüller's Institute has already obtained a kind of international reputation. It will ultimately develop into a kind of international centre for the scientific development of lighting. It will profit from its extremely favourable geographical situation, in the centre of the western part of the Continent.

[*We are indebted for the illustrations accompanying this article to "Das Licht" (Verlag Alexander Ehrlich, Berlin), in which a full description of the Karlsruhe Institute recently appeared.*—ED.]

Literature on Lighting

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

(*Continued from Page 3, January*, 1932)

Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. H. M. Cotteril, Mr. J. S. Dow, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. W. C. M. Whittle and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—ED.

I.—RADIATION AND GENERAL PHYSICS.

17. A Correlated Colour Temperature for Illuminants. Raymond Davis.

Bureau of Standards Journal of Research. Vol. 7, p. 659, Oct. 4, 1931.

The colour of light from artificial and natural illuminants does not match exactly any one of the Planckian colours, and cannot be assigned a colour temperature, though it may be correlated with a representative Planckian colour: the relative luminosities of each of the three primary red, green, and blue components of the source being compared with similar values for the Planckian series. Three component temperatures are thus obtained and their mean is termed the correlated colour temperature. The mean deviation of the component temperature from the average temperature forms a measure of the colour departure of the source from that of the Planckian radiator at the correlated colour temperature. W. B.

18. A Vacuum Iron Arc Lamp.

Journal of Scientific Instruments, Vol. 8, No. 8, p. 266. August, 1931.

Zeeman has designed a vacuum iron arc lamp which offers advantages for spectroscopic purposes, namely: (1) No water cooling. (2) The electrodes can easily be interchanged. (3) No parts of the lamp house are under tension. (4) Ignition and adjustment of the electrodes with the same knob. (5) The arc lamp burns in the most constant way at a vacuum of about 4 cm. Hg.; this vacuum can be kept up by means of a filter pump. (6) Constant arc. Apt for continuous work. (7) The emitted light gives very fine spectral lines. At a current of approximately 3.5 amp. the temperature of the lamp house does not exceed 70°C. W. B.

19. The Relative Spectral Energy Distribution and Correlated Colour Temperature of the N.P.L. White Light Standard. R. Davis and K. S. Gibson.

Bureau of Standards Journal of Research. Vol. 7, 5, p. 791. Nov., 1931.

The spectral characteristics of the two Guild-Young filters have been deduced from their specifications. Computations indicate that the chromaticity of the first source—and filter combination approximates closely that of a Planckian radiator at 2,931°K. Using as a source the relative spectral energy-distribution corresponding to 4,831° K in combination with the second filter, the authors have obtained the spectral energy-distribution and the chromaticity of the N.P.L. white light standard, which is approximately that of a Planckian radiator at 4,831°K. Comparison is made with the Davis-Gibson source-filter combination for obtaining a colour temperature of 4,800°K. W. B.

20. A Balanced Thermocouple and Filter Method of Ultra-Violet Radiometry, with Practical Applications. W. W. Coblentz and J. M. Hogue.

Bureau of Standards Journal of Research. Vol. 7, 4, p. 723. Oct., 1931.

An experimental procedure is described for testing the performance for the standardization of photo-cells as ultra-violet dosage meters; also for using measured amounts of ultra-violet in physiological experiments using spectrally homogeneous (monochromatic) and heterogeneous ultra-violet radiation. W. B.

II.—PHOTOMETRY.

21. Direct-Reading Illuminometer. Anon.

Electronics, p. 422. Dec., 1931.

A new Portable Illuminometer (Weston Model 603) has been developed by the Weston Electrical Instrument Corporation, Newark, N.J. Direct measurement of illumination in foot-candles is effected by turning the searching unit to the light to be measured. The instrument consists of a meter mounted in a carrying case attached to a searching unit by a 6-ft. cable, the whole outfit weighing 7lbs. G. S. R.

22. A Cylindrical Rotating Sector Photometer. F. Lowell Dunn.

Rev. Sci. Instruments, 2, pp. 807-809.

The sector described resembles a cone drill or hole saw with two teeth. A beam of light is passed into the revolving cylinder parallel to its axis of revolution and is then reflected radially by a prism. This type of sector permits a continuous variation of transmission from 0 to 100 per cent. F. J. C. B.

23. Instruments for the Measurement of the Brightness of Radioactive Luminous Compounds. H. F. Meacock and G. E. V. Lambert.

Journal of Scientific Instruments, Vol. 8, No. 7, p. 214.

Instruments are described for the measurement of luminous compounds of brightness of the order of 0.02 candles per square ft. One instrument is used for surfaces larger than about 6 mm. diameter; the other, embodying the Maxwellian view, for smaller surfaces. In both cases opal glass, illuminated through a green colour screen by a standard lamp running along a photometer bench, forms the comparison surface. The instruments are calibrated by an absolute method over a range of brightness from 0.002 to 0.03 candle per square ft. Over this range the reproducibility obtainable is about 2% for the first instrument and within 10% for the second instrument in which the Maxwellian view is utilized. W. B.

IV.—LIGHTING EQUIPMENT.

24. A New Warning Beacon. R. H. Gessford.

Elect. J., Vol. 28, 12, *p.* 695. *December*, 1931.

An electrical circuit comprising two neon grid-glow tubes with suitable resistances and capacities is so arranged that the two tubes glow alternately, and can be used as a warning sign for road crossings, etc. No moving parts are used, and the circuit is operated from a low-voltage A.C. supply. J. M. W.

25. Study of the Luminous Flux Reflected by a Concave Right-angled Dihedral and a Concave Right-angled Tetrohedron. L. Dunoyer.

Rev. d'Optique, Vol. 10, 11, *p.* 437. *Nov.*, 1931.

A study of the action of roof reflectors and tetrahedral reflectors, the use of which is becoming general for warning signs and other devices of the "flash-back" type. A roof reflector will only return the whole of the flux incident upon it when it is incident on the bisecting plane of the reflector: a tetrahedral reflector cannot reflect more than two-thirds of the incident flux at any time, the maximum efficiency occurring when the flux is incident along the ternary axis. For angles of incidence of less than 19.5°, the efficiency is independent of the orientation of the reflector about this axis. The usefulness of these reflectors is diminished by the rapid decrease in efficiency with increase in angle of incidence, and the correspondingly limited field of good visibility of the signal. J. M. W.

26. Ultra-Violet Fittings. H. G. Schiller and W. C. Clemson.

Light, 2, *pp.* 30-31, *Nov.* 1931, *and pp.* 34-35, *Dec.*, 1931.

Describes with photographs a number of American reflector units using S2 sunlight lamps. The fittings include those for ceiling fixing, and also for floor and table standards. C. A. M.

27. Lamps and Reflectors. D. Charles.

Brit.J.Photog., Vol. lxxviii, No. 3737, *pp.* 751-53.

Advice is given on the selection and operation of lighting units for photographic studios. F. J. C. B.

28. Carrier-Current Street Lighting Control. R. E. Curtis.

El. World, 98, *pp.* 1130-32. *Dec. 26th*, 1931.

Describes the series street lighting used in Springfield, Mass. The apparatus failed to function in only about 0.05 per cent. of the operations required. This installation is the second of its type to be installed in the U.S. W. C. M. W.

V.—APPLICATIONS OF LIGHT.

29. Lessons from Europe. M. Luckiesh.

Light, 2, *pp.* 11-13, *Dec.* 1931. *See also El. World, pp.* 1094-8. *Dec.* 19*th*, 1931.

The author discusses the various influences in Europe involved in a comparison of American and European progress in lighting. Such influences may be sociological, economic or historic. He regards Berlin as the best lighted city in Europe. Photographs of the French Colonial Exposition are included. C. A. M.

30. Interim Report: Committee on Light in Architecture and Decoration. Anon.

Am. Illum. Eng. Soc., Trans. 26, *p.* 872. *Nov.*, 1931.

Eight illustrated descriptions of lighting installations. G. H. W.

31. Display Lighting. H. E. Hutter, A.Am.I.E.E.

El. Rev., Vol. 109, *p.* 953. *Jan.* 1*st*, 1932.

Coloured light carefully applied enhances displays, giving a richer appearance than when white light only is used. By mixture of the three primary colours (red, green and blue) it is possible to obtain any desired colour. G. S. R.

32. Light in Europe, 1931. O. P. Bernard.

Light, pp. 23-25, *Dec.*, 1931.

Reviews recent progress in architectural lighting in Europe. Ordinary lamps do not lend themselves to this type of lighting, and that special types and shapes should be designed for the purpose. Photographs are presented illustrating the use of strip-lites and tubular lamps in England and Germany, and progress in their manufacture is recorded. C. A. M.

33. A Big Job Well Done. Anon.

Light, 2, *pp.* 26-27. *Dec.*, 1931.

The general lighting of the new Philadelphia Municipal Auditorium is obtained from a large laylight. 900 kw. is used in providing white, red and blue lighting. 20 foot-candles are obtained on the reading level 100 ft. below the laylight. Equipment taking 600 kw. is available for stage lighting. The installation is a good example of early co-operation between architect and illuminating engineer. C. A. M.

34. Lighting of the New Waldorf-Astoria Hotel. L. H. Graves.

Am. Illum. Eng. Soc., Trans. 26, *pp.* 939-47. *Nov.*, 1931.

Gives details of the installation in this hotel and of the equipment employed. Many of the units are indirect and cove lighting of a model form is employed in one room. Photographs are reproduced. G. H. W.

35. A Cloak of Light for Miss Liberty. A. Paulus.

Am. Illum. Eng. Soc., Trans. 26, *pp.* 959-64. *Nov.*, 1931.

Details are given of the new floodlighting installation on the Statue of Liberty. The layout of the projectors is described, and details of the problems requiring solution are given. G. H. W.

36. The Correct Lighting of Looms. N. Goldstein and E. Putnoky.

Das Licht, 13, 325. 1931.

Experiments were carried out on the lighting of looms of different sizes and making different types of materials. Based on the results, recommendations are made as guides to the choice of the illuminating units, their number and arrangement, and the determination of the necessary wattage. For lighting looms of medium breadth weaving light-coloured material, two 100-watt lamps are recommended for the front of the loom and two 60-watt lamps behind. For dark-coloured materials the corresponding figures are two 150-watt and two 75-watt. Data is given showing the speed of working under different intensities of illumination and different arrangement of units. S. E.

37. Psycho - Technical Determination of the Economical Optimum in the Illumination of Textile Mills. N. Goldstein and E. Putnoky.

Journ. Fr. Inst., 212, *pp.* 613-632. *Nov.*, 1931.

This is a translation of the articles which appeared in *Licht und Lampe*, 20, 1931. S. S. B.

VI.—MISCELLANEOUS.

38. Eyesight Conservation in the Home. M. Luckiesh

El. World, 98, *pp.* 1127. *Dec. 26th*, 1931.

The author urges improvement in residential lighting, and states that ' while æsthetic considerations govern the method of lighting the home in general, visual efficiency should be the object of lighting of certain places where exacting visual work is done." W. C. M. W.

39. Paints for Reflecting Biologically - important Ultra-Violet Radiation. M. Luckiesh and L. L. Holladay.

Frank. Inst. J., 212, *pp.* 787-95. *Dec.*, 1931.

The radiation band investigated is 2800 to 3200 A. Data are presented for various pigments, commercial paints and wall-papers, and representative mixtures of materials of possible application. S. S. B.

40. Size of Object, Visibility and Vision. C. E. Ferree and G. Rand.

Am. Illum. Eng. Soc., Trans., 26, *pp.* 820-856. *Oct.*, 1931.

The effect of changes in size of object and speed of discrimination is studied for different intensities of illumination and different relations of object to background. Possible methods for the measurement of the visibility of objects are discussed, and one is selected as the most feasible for the purpose of this study. In terms of this method visibility is measured for details subtending visual angles of 1, 2, 3, 4 and 5 minutes of arc at intensities of illumination ranging from 1.25 to 100 foot-candles and for six relations of object to background, and the corresponding ratings are made for vision of each of these conditions. A comparison is given of the results obtained and the conventional ratings in terms of the visual angle scale. G. H. W.

41. Variation of Photographic Sensitivity with Different Light Sources. R. Davis and G. K. Nuland.

Bureau of Standards Journal of Research, Vol. 7, 5, *p.* 843. *Nov.*, 1931.

The variation of photographic sensitivity (as measured by the index $10/E_m$) with different light sources of equal visual intensity, but having different distributions of energy, was experimentally obtained. Approximate factors are included (for the particular emulsions studied) by which visual exposure-meter readings should be multiplied when certain types of illuminants are encountered. W. B.

42. Photo-cells: the Valves which Operate by Light. C. C. Paterson.

Nature, Vol. 129, *No.* 3245, *p.* 66. *Jan. 9th*, 1932.

Abstract of a lecture delivered at the annual exhibition of the Physical and Optical Societies, 1932. The general properties of the different types of photo-electric cells are briefly described. J. M. W.

43. A New Illumination Device for Microscopy.

Nature, Vol. 128, *p.* 1010. *Dec. 12th*, 1931.

Describes a new illumination device for the illumination of opaque microscope specimens by means of an annular beam of light surrounding the objective, which is provided with its own condensing system surrounding the image-forming system. J. M. W.

British Standards Institution

(A Joint Meeting by Wireless with the Standards Association of Australia).

UNDER novel circumstances a joint meeting of the British Standards Institution and the Standards Association of Australia was held on January 14th, at the offices of the Board of Trade in London, and Science House, Sydney, the speeches being transmitted by wireless between the two assemblies.

Colonel Sir Thomas Purves, who presided in London, read a cablegram from the Prime Minister of Australia, expressing the Australian Government's interest in standards, and stating that the Government looked forward confidently to the visit of Mr. C. le Maistre, Director of the British Standards Institution (who was present at Science House), to provide means for closer co-operation.

Mr. Walter Runciman, President of the Board of Trade, emphasized the value of standardization in promoting the growth of inter-Imperial trade. The Imperial Conference in 1930 warmly endorsed the recommendations of the Conference on Standardization. H.M. Government in the United Kingdom viewed with keen appreciation the cordial relations which existed between the Standards Institution in this country and the Association in Australia.

The British Standards Institution was supported by the British Government, and in spite of financial stringency it had recently received a substantially increased grant from the Board of Trade. The Institution had, however, to be primarily an industrial movement, and it claimed the fullest possible support from industry. Individual firms could aid by becoming members of the Institution and by actively supporting the adoption of national standards.

Sir George Julius, Chairman of the Standards Association of Australia, speaking in Sydney, said the trend of world affairs in past years illustrated the necessity for the stimulation of inter-Empire trade. Britain was realizing more and more the need for extending further her Empire markets. Both countries were realizing more and more their mutual interdependence. Not the least of the efforts being made towards the study of mutual requirements was the work of the Standards Associations in Great Britain and Australia, and the other parts of the Empire.

Mr. Maurice Wilson, the Chairman of the British Standards Association, Sir William Larke and Sir Thomas Purves also spoke from this side, and Sir Henry Barraclough and Mr. le Maistre from Sydney. The transmission during the whole meeting was excellent, and the meeting was included in the broadcast programme in Australia.

As the readers of *The Illuminating Engineer* probably know, the British Standards Institution began life in 1901 as the Engineering Standards Committee, became in 1918 the British Engineering Standards Association, was incorporated by Royal Charter in 1929, and has just received a Supplemental Royal Charter whereby it is incorporated as the British Standards Institution, and is authorized to extend its consideration of standardization questions as they arise, not only in the engineering industry but in the chemical, building and textile industries.

Although it is supported by the Government and representative organizations, the British Standards Institution is an entirely independent body, and is free from Government control. It exists to assist British industry, and has to rely on industry for the larger proportion of the funds required to carry on its work. Every British firm and every individual connected in any way with any of the sections which the Institution covers is eligible to become a member of the Institution at a nominal fee. Membership carries with it some valuable privileges and advantages, and the co-operation and assistance of all manufacturers and others in the engineering industry are sought for the promotion of the Institution's work.

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—Data for Contractors—Hints to Consumers

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society and is based on outside contributions.)

Why Illuminated Traffic Signals are Better

(Communicated by the E.L.M.A. Lighting Service Bureau).

WITH the number of road users increasing with great rapidity we have to-day a difficult problem of determining the most suitable and economic method of traffic control; assuring safety for both pedestrian and vehicular traffic.

It is of utmost importance that a high standard of mobility should be maintained wherever traffic densities are high, and one of the principal aims of all traffic controllers should be the maintenance of a good average speed. It is the only way to minimize congestion.

The lighted traffic signal which originated in the United States, and which is now completing its experimental stages in England, has contributed in no small way towards providing a system of control incorporating the foregoing features. The point-policeman method of traffic control has certain disadvantages, and often leads to misinterpretation on the part of the motorist of the signals given, although a great deal has been accomplished in the standardization of hand signals. Further, the distance at which hand signals can be seen is limited. In comparison, the lighted traffic signal has a minimum visibility of 300 ft., and gives an unmistakable signal—a powerful red light for "Stop" and a green light for "Go," together with a warning signal denoting the change from one to the other.

The introduction of these signals has invariably led to an increase in the speed of traffic, and from tests made both in the United States and Great Britain since their installation, it has been found that the time taken to traverse a measured distance has been reduced by some 50 per cent.

Systems.

There are three general systems of control, namely: (1) the synchronized system, (2) the progressive system, and (3) the co-ordinated system, but all embody the same principles of operation in providing centralized control, although they differ somewhat in their cycle of operations.

The progressive system, which is a further development of the synchronized system, has proved to be the most popular of all methods, as it takes into account the various lengths of "blocks" met with in different localities. The system is arranged so that the signals along any particular street are staggered, alternatively displaying red and green.

The uniformity of their design and construction, and the standardization of the positions relative to the direction of traffic flow, has rendered it possible for road users to speedily become acquainted with them.

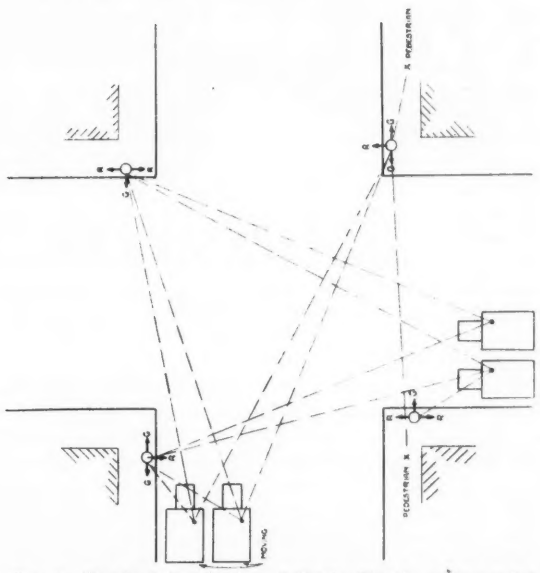


FIG. 1.—Standard Installation of Traffic Signals recommended by Ministry of Transport (Roads Memorandum, 297).

Advantages to Traffic.

The system is set to a predetermined speed of travelling, and it follows therefore that, knowing this speed, a vehicle starting at the beginning of the street on the green light can travel through from end to end without stopping. The time signal is short, and should a motorist fall out of step or enter the street when the red signal is displaying, he has only a short wait before he can proceed. In the lighted traffic signal, therefore, we have a system of control which enables traffic in both directions to

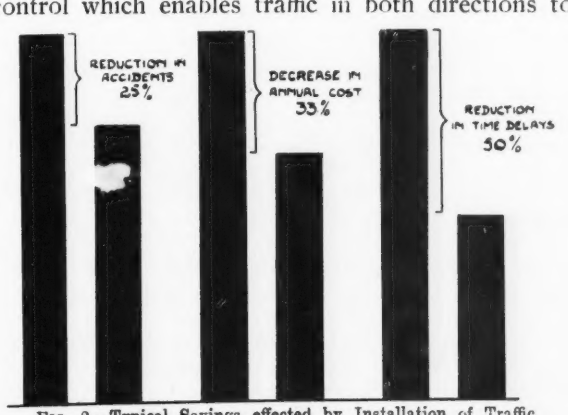


FIG. 2.—Typical Savings effected by Installation of Traffic Control Signals.

flow more or less continuously, and consequently the likelihood of congestion is very remote unless there is an extraordinary volume of traffic, in which case the system provides for the independent control of individual signals. The introduction of luminous traffic signals have had a great influence in the extinction of " speed merchants," who persisted in racing through the streets to the danger of the common public, for, should a motorist exceed the speed at which the signals are timed to operate, he will be called upon to make frequent stops, and this being a constant source of annoyance has a considerable influence upon his speed.

Reduction of Accidents.

When the installation of traffic signals was proposed it was found necessary to restrict certain left- and right-hand turns in order to facilitate the continuous movement of traffic streams. In order to make this effective one-way street orders were put into operation, and consequently the volume of traffic was distributed over a wider area. From this we can infer that lighted traffic signals tend to reduce street accidents, which are roughly proportional to traffic densities and congestions. Although definite figures are not available of any reduction in accidents that traffic signals have effected in this country, Chicago noted a reduction of almost 25 per cent. during the period of five months immediately following their installation. It has been found that pedestrians will more readily obey the signal if only a short period elapses before they can cross the intersection and the signals are noted by them as well as by vehicular traffic. Inasmuch as the pedestrian suffers more than any other group from street accidents, this is an important factor.

Financial Advantages.

The economic aspect is a very important and convincing one, showing the enormous saving made by the installation of lighted traffic signals; in fact, upon this score alone they have been installed in provincial areas where the local income is comparatively small. At the annual meeting of the New York Electrical Association, in February, 1928, the Deputy Police Commissioner in charge of traffic intimated that the New York City had effected a saving of 12,500,000 dollars by the installation of 2,500 such signals, which had eliminated the necessity of 5,000 traffic policemen. Another instance of economy is in Edinburgh, one of the first cities in Great Britain to install automatic traffic signals. The Chief Constable reported that 17 crossings were being provided with these signals at a cost of £3,360 and an average annual maintenance cost of approximately £297. Comparing this with £4,680, which was the annual expenditure under the police system of control, it is seen that the first year's saving amounted to approximately £1,000, which would be materially increased in subsequent years.

In general, the installation cost per signal way is approximately £150, and the annual maintenance of the order of £50. In comparison, the average cost of a police constable, including wages, uniform, housing and provision for pension, is about £300 per annum, and at some intersections the installation of signals relieves two officers.

The Government pays one-half of the cost of police engaged in traffic control, while the remaining half is borne by the local ratepayers, which is an unfair burden, especially where a large volume of traffic passes through from which they derive no benefit. This is not to the advantage of the motorist, as it is liable to arouse a feeling of ill-will on the part of the ratepayers towards mechanical transport. Further, it leads to hostility between road transport and railway authorities, the latter pointing out that not only do road users have their permanent way made for them but their signalling is also provided. If this cost is kept to a minimum the well-being of the community in general will be assured.

Traffic signals supply a useful load to supply undertakings, as they operate at a high load factor. For example, in London the 189 sets of signals installed in Oxford Street provide a load of approximately 11 kilowatts for 16 hours daily, or 176 units per day at a load factor of 67 per cent.

The superiority of this method of traffic control is shown by the increasing number of authorities adopting it and by the extension of experimental installations.

Hitherto, night transport has been decidedly unpopular owing to the inadequacy of warning-signs visible by night, but by the presence of illuminated traffic signals and the introduction of warning-signs and notices much has been accomplished towards relieving the roads by day of traffic which could conveniently use the night.

Sheffield Illumination Society

The seventh annual social of the Sheffield Illumination Society, which took place at Stephenson's Exchange Restaurant, Sheffield, on January 12th, was graced by the presence of the Lord Mayor and Lady Mayoress of the City (Alderman and Mrs. T. H. Watkins) and Councillor P. J. M. Turner, a member of the City Street Lighting Committee.

In the unavoidable absence of Councillor R. H. Minshall, Mr. J. F. Colquhoun, the Lighting Engineer and Honorary President of the Society, presided. Reference was made to the great increase in public lighting during the past seven years. The number of lamps had increased from 11,000 in 1924 to over 20,000; the candle-power increased from half a million to about two and a half millions; the labour cost per lamp per annum had been reduced by 16s. 11d., which was equal to over £17,000 per annum, or, if the labour costs were related to candle-power, it was found that in 1924, the labour cost per one candle-power was 10½d. and to-day 2½d. The Sheffield Illumination Society had a good deal to do with that marked improvement, because it was brought about by increased efficiency, and the papers read at the meetings of the Society and the discussions thereon helped in no inconsiderable way to the attainment of that high efficiency. The removal of the Department's Offices, Stores and Workshops from the old, unsuitable, " slummy " premises to the new and commodious premises at Matthew Street was referred to.

Mr. Colquhoun asked members to note specially the 7th November next, as the Society had the good fortune of procuring for that date Professor W. E. S. Turner, D.Sc., M.Sc., Sheffield University, to give them a lecture on " Glass in the Service of Illumination." The meeting terminated with a musical programme and whist drive, the prizes being presented by Mrs. Colquhoun.

We have since received a copy of the programme of the Society for the coming session. Of chief importance is Professor Turner's address, mentioned above. There is also a contribution by Mr. M. G. Lockwood on " Testing Department Work," and a number of interesting visits and social events have been arranged.

It is evident that the Society is continuing to serve a useful purpose in keeping members of the staff in contact and furnishing an agreeable blend of entertainment and instruction.

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and brighten night
With full, efficient,
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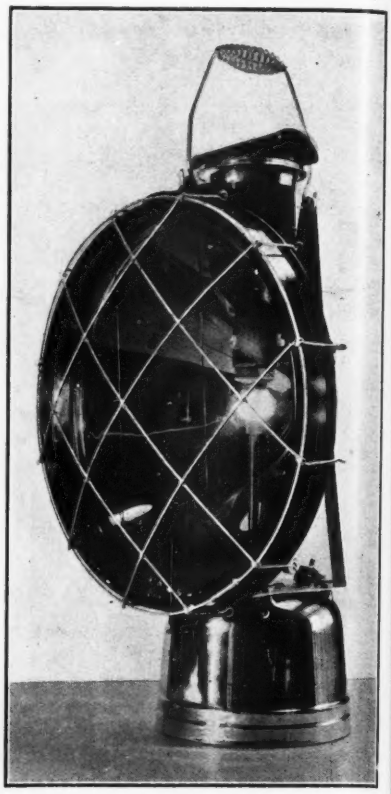
Incandescent Oil Floodlighting

Experiences during the meeting of the International Illumination Congress in London last September served to show how effectively floodlighting can be done with incandescent gas equipment; but it is perhaps less generally known that incandescent oil lamp projectors are also being successfully applied for commercial floodlighting. For some time Tilley incandescent oil lamps of various types have been widely used on all four of the leading British railway systems—for example, for lighting country station platforms. More recently, floodlight projectors, of

Tilley Floodlight Projectors in use to assist constructional work on the Ilford and Barking Joint Sewerage Scheme.

the type illustrated above, have also been proving of considerable service. The projectors burn paraffin vapour and use a special silk mantle, backed by a reflector with chromium-plated surface; the necessary air pressure may be obtained by applying an ordinary cycle pump. A 1,000-candle-power unit holds sufficient oil for 20 hours' continuous burning, and is stated to give six hours' light for 1d. This form of unit is indeed exceptionally well adapted for constructional work where a lighting unit that is both powerful and portable is needed, and which is often done in circumstances such that neither gas nor electricity is available. We are also indebted to the Tilley Lamp Co., of Hendon, for the night-photograph showing the use of these projectors to facilitate night work by Messrs. Howard Farrow Ltd., the well-known contractors, in connection with the Ilford and Barking Joint Sewerage Scheme.



General View of Tilley 1,000 candle-power Floodlight Projector.

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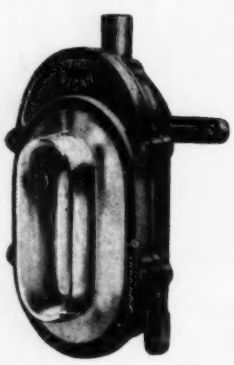

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The above reproduction shows one of the REVO three-arm brackets supporting three lanterns which, together with two-arm brackets for two lanterns, are used throughout the length of this well-known elevated promenade. The Brackets and Fittings were specially designed and manufactured by Revo Electric Co., and in spite of formidable limitations in the scheme, the result shows that illumination between the units is now more than double the amount previously obtained for the same current consumption. This installation proves again that artistic appearance has involved no sacrifice of efficiency.

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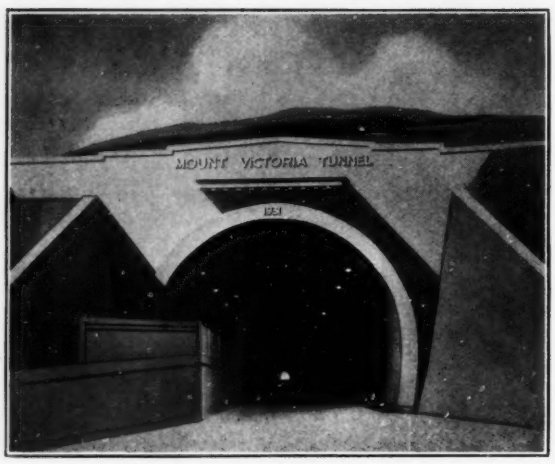
TRADE NOTES & ANNOUNCEMENTS

The Lighting of Mt. Victoria Tunnel, New Zealand

The accompanying illustration, which shows the new Mount Victoria Tunnel, in Wellington, New Zealand, was taken in broad daylight. Hence it scarcely does justice to the lighting of the interior, which has interesting features. The tunnel, which is 2,045 ft. long, is of great national importance in New Zealand. It is the outcome of many years of deliberation and construction, was built in record

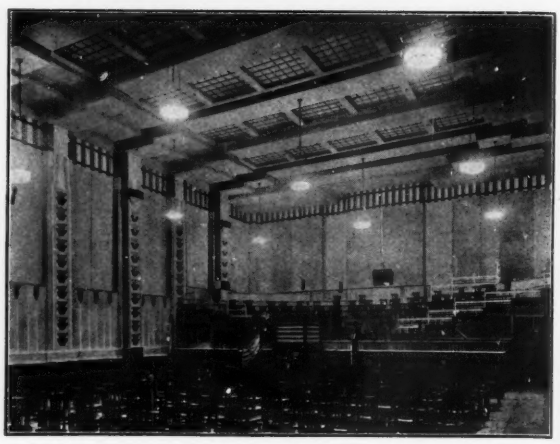


A View at the Entrance to Mount Victoria Tunnel. The exit, 2,045 ft. distant, can also be seen.

time at an overall cost of £203,000 and is regarded as a thoroughly first-class job. The lighting of this tunnel is achieved by means of 120 Benjamin Rodalux fittings, which are specially spaced so that the illumination is graded, and the eye, on passing from broad daylight into darkness, is gradually accustomed to the change.

Holophane Lighting in the new H.M.V. Recording Studios

The adjacent picture shows the interior of the new hall, built by the Gramophone Company in connection with the H.M.V. Recording Studios. This hall is 130 ft. long, 50 ft. wide, and 30 ft. high, having thus a cubic capacity of about 200,000 cubic feet. The platform can accommodate 250 players and the auditorium about 1,000 people, so that the studio is nearly as large as the Queen's Hall, and considerably larger than the Kingsway Hall. The construction of the hall has been the subject of special study. The wells are designed to give the correct resonance to all sounds, and to avoid any echo. A special system of air cleaning and ventilation has been installed so as to furnish an atmosphere such as will enable artists and musicians to perform during any period of the year under the most favourable conditions. The lighting is solely by artificial means. Twelve Holophane Hedralite Octagonal Drum Fittings of impressive dimensions are installed. The Hedralite system, it may be recalled,



The New Hall, lighted entirely by artificial means, attached to the H.M.V. Recording Studios.

enables lighting units of varied shapes and sizes to be built up, ranging from a small bracket to a huge laylight, to suit any combination of lamps or size and type of building.

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The Air Ministry: for the supply of a large number of special navigation lamps for aircraft.

The Warrington Borough Council: for a six months' supply of Siemens gasfilled lamps.

The Union-Castle Mail Steamship Co. Ltd.: a further contract for a six months' supply of Siemens vacuum and gasfilled lamps.

The Waldram Daylight Factor Gauge

A considerable amount of interest was shown in the Waldram "Daylight Factor Gauge" exhibited at the opening meeting of the Illuminating Engineering Society, and described in our December (1931) issue, page 313. Readers may be interested to know that this device, which is fully described under Patent Publication No. 29047/31, can now be obtained from Messrs. Everett Edgcumbe & Co. Ltd.

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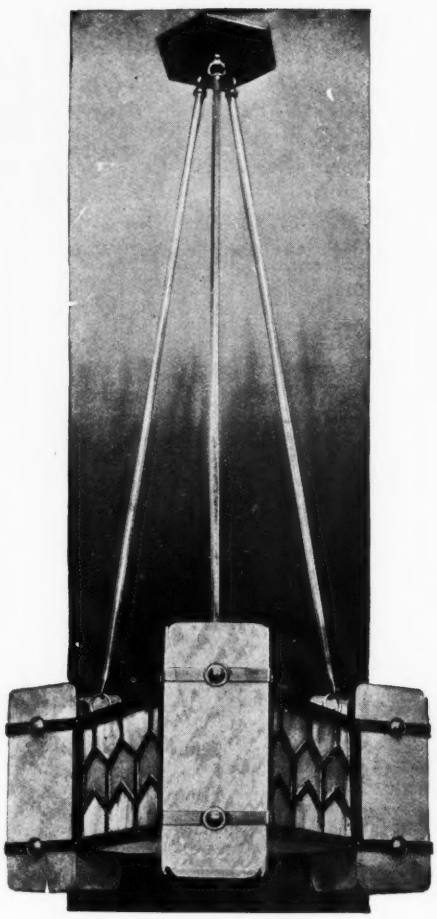

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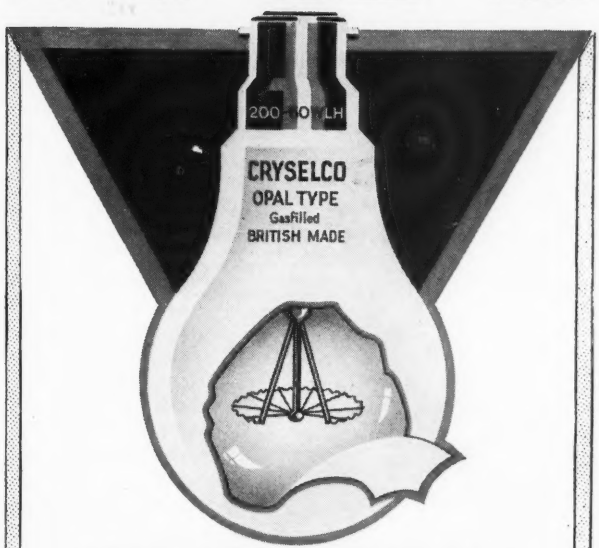

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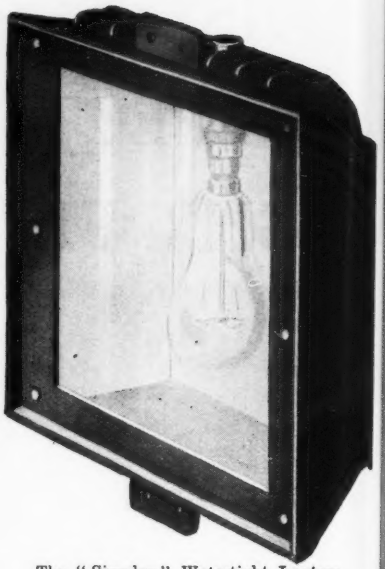
Simplex Specialities

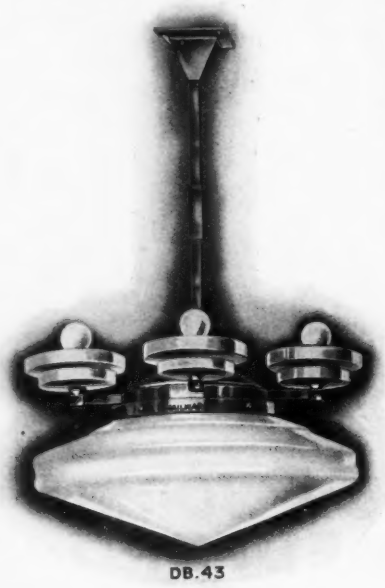
A recently issued catalogue of Simplex Electric Lighting Equipment (List No. 1280) contains full particulars of standard lines of steel reflectors and weatherproof and watertight lanterns, but there are also several somewhat unusual types of fittings that deserve mention. Amongst these is a convenient trough reflector for floodlighting shop fascias, etc., and a watertight lantern (shown in the accompanying illustration). This is specially designed for use in factories concerned with explosive materials, and in other cases where the Home Office regulations demand the provision of lighting fittings that can be mounted *outside* the building (so that the light can be directed through a window). We also notice a neat and compact prismatic lighting unit, which occupies very little space and appears particularly adapted to the illumination of corridors; an illustration in the catalogue shows its application to the lighting of gangways in warehouses where good vertical illumination on the adjacent racks is desirable but is not always easy to achieve.



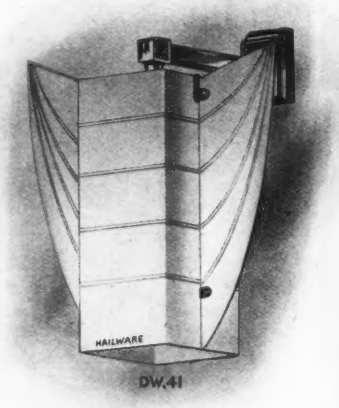
The "Simplex" Watertight Lantern.

British-made Glassware

We reproduce two pleasing illustrations of fittings, one a bowl pendant unit, the other an unusual form of bracket light, which are taken from some recent literature sent us by Messrs. Hailwood & Ackroyd Ltd. A recent list of "Hailware" panel pendant fittings illustrates the enterprise with which this firm has taken up the production of lighting units of the modern "architectural" type. Some of these, built-up decorative glass in geometrical patterns, are illustrated in colour. Besides pendants and wall brackets, there are ceiling and trough fittings and numerous strip designs for adaptation to cornices, pillars and mirrors. In the final section of the catalogue are designs for architectural illuminated balustrates, balcony or orchestra platform fronts, and even illuminated stairways—all executed in patterned diffusing glass. The variety of types illustrated is really remarkable, considering the comparative novelty of these "architectural" designs, and it is certainly satisfactory to think that they are entirely produced in this country.



A novel "Hailware" Bowl Pendant Fitting.



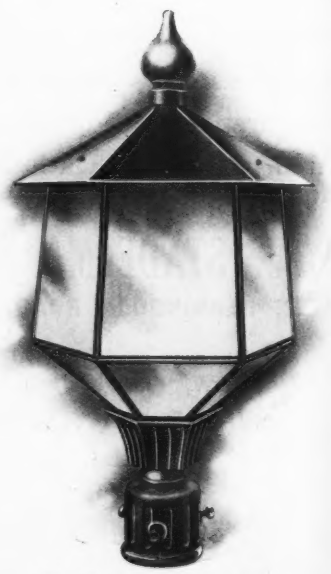
An unusual form of Bracket Light.

Floodlighting at the International Illumination Congress

Several leaflets commemorating the floodlighting display of September last have appeared, amongst them a four-page display of the chief Holophane installations. The Big Ben and Westminster Abbey installations attracted widespread attention, and the lighting of the Deptford Power Station, the L.C.C. School of Engineering, and other buildings was illustrated in this journal; there are, however, quite a number of others depicted. Another attractive memento is the G.E.C. booklet, "Britain Illuminated." This has as frontispiece a reproduction in colour of the lighting of the Carreras factory. Buckingham Palace, Thames House and other outstanding installations are included. But there are many others less familiar; and several pleasing views of floodlighting effects in gardens are shown.

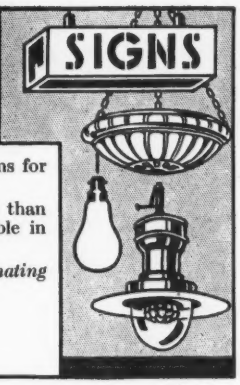
The Peterborough Lantern

A leaflet sent us by the Electric Street Lighting Apparatus Co., of Canterbury, contains a variety of designs of street-lighting units, amongst them the distinctive but now familiar "Peterborough" lantern, a general view of which is reproduced. We understand that this particular lantern was designed by Commander Haydn T. Harrison, in conjunction with Mr. H. A. Nevill, the Electric Engineer of Peterborough, in the year 1923, when about 500 were manufactured and supplied to that city. It has since become widely adopted. We have also to acknowledge the receipt of a pamphlet illustrating some of the installations carried out by the Electric Street Lighting Apparatus Co. in London and its environs. It is stated that the sections of installations illustrated total well over 400 miles of roadway, all within 12 miles of Charing Cross.



The Peterborough Lantern.

·WHERE TO BUY·
A DIRECTORY OF LIGHTING EQUIPMENT



We invite applications for spaces in this new section of the journal. Particulars of terms for each space (approx. 1 inch deep and 3½ inches wide) are given below.

These terms are equivalent to **half our ordinary advertising rates**, but not less than 12 successive monthly insertions can be accepted on this basis, and amounts are payable in advance.

Payment for an advertisement in this section entitles the advertiser to receive *The Illuminating Engineer* during the period of the contract.

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	36	,, ,, ,,	**£8 10 0**	}	Advance

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Theatres and Public Halls. Private Installations
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Modern Arc Lamps for Street Lighting. Silent Arcs for Film and Photographic Studios.

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Specialists in Light Sensitive Work
AUTOMATIC CONTROL OF STREET AND FACTORY LIGHTING
Increasingly in demand as the most efficient and economical control
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THE LAMPLOUGHT DAYLAMP. The most accurate form of Artificial Daylight.

RESTLIGHT. Corrected to resemble natural light, saves the eyes; for use in Home, School, Office, Factory, in fact everywhere.

100% BRITISH
NORWICH HOUSE, 13, SOUTHAMPTON STREET, W.C.1

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ELECTRIC LAMPS of all types. ELECTRIC LIGHT FITTINGS FLOODLIGHTING APPARATUS. SHOP-WINDOW LIGHTING EQUIPMENT. STORE LIGHTING. INDUSTRIAL LIGHTING. ELECTRIC SIGNS, Etc.

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Specialists in Modern Theatrical Lighting
Manufacturers of "Sunray" Lighting Equipment
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TROUGHTON & YOUNG LTD.
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MODERN LIGHTING FITTINGS

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WARDLE ENGINEERING Co. LTD.
OLD TRAFFORD, MANCHESTER

STREET LIGHTING EQUIPMENT. TRAFFIC SIGNALS.
PRISMAT BULKHEAD FITTINGS. FLOODLIGHT PROJECTORS.
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"THE FITTINGS THAT IMPROVE WITH AGE" (14)

WOODFYT
10a, NEWMAN STREET, W. 1
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Catalogue sent on application

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(15)

The Wolf Safety Lamp Co.
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SOUTH STREET, PARK, SHEFFIELD

Specialists in ELECTRIC HAND LAMPS with Wolf Alkaline accumulators for Mines, Railways, and General Purposes.
ACETYLENE LAMPS (150 models).

Illuminating Engineering Society (U.S.A.)

Twenty-Sixth Annual Convention

As we go to press we learn that the twenty-sixth annual convention of the Illuminating Engineering Society (U.S.A.) has been arranged to take place during the week of September 26th, 1932, at the New Ocean House, Swampscott, Mass. It may be recalled that the sixteenth annual convention, in 1922, was held in the same pleasant locality.

We have not yet received detailed particulars of the programme, but we understand that an interesting series of papers has been arranged; no doubt the method of grouping a number of papers on various aspects of the same problem in a single session will be again adopted.

The Illumination of Ripon Cathedral

ALTHOUGH Ripon Cathedral dates back many centuries, its actual origin is obscured in the mists of antiquity. It is said to rest on a site given by King Alchfrid of Northumbria in A.D. 661. Later the site was handed to Wilfrid, referred to by ancient writers as Saint Wilfrid, who some time later became Archbishop of York. A quaint custom still survives in Ripon to link up St. Wilfrid of those early days with the present time. The first Saturday in August each year is known as "Wilfrid Saturday," and a man impersonating the bishop rides through every street in the city on horseback, preceded by a band playing music.

FIG. 1.—The Original System of Lighting.

The old church suffered severely at the hands of the Danes about A.D. 950. Subsequently it was rebuilt and additions were made in 1154 and 1181. It was set on fire by the Scots in 1332 and in 1459 was again restored under special indulgence granted by Henry VI. In 1836 an Episcopal See was erected and thus Ripon Cathedral came into being as a Cathedral.

This recapitulation of early history may serve to indicate the importance of Ripon Cathedral throughout the centuries. The prevailing architecture to-day is Gothic. The nave presents one of the finest specimens of the pointed arch to be found anywhere in the Kingdom. There is, however, also a mixture of both rounded and pointed arches belonging to the Transition period in the central portion and also in the choir.

In designing a system of electric lighting for a building such as Ripon Cathedral regard had to be paid to the preservation of all the architectural features of the different sections. The wiring had to be run in such a way that it would cause no damage or disfiguration, and it was felt that the lighting apparatus should be unobtrusive. As is evident from Fig. 2 the actual light-sources are invisible, neither is there any trace of the wiring. As a contrast, in the original lighting (Fig. 1) the light-sources were clearly visible and likewise the channels of supply.

GECoRAY floodlights and reflectors equipped with Osram lamps of from 100 to 500 watts have now been adopted for the whole of the general lighting of the cathedral. In the nave, at clerestory level some 60 ft. from the floor, eighteen 500-watt floodlights are concealed behind the pillars and directed eastward at an angle of about 45°. This lighting also serves to illuminate the aisles, but for this purpose is supplemented by a similar number of 150-watt floodlights concealed at higher levels. Agreeable features are the softness of effect, the absence of glare and the balanced effect of the lighting which enables the architecture of the cathedral to be easily seen and appreciated. The North and South Transepts, with their lofty system of lighting by 200-watt floodlights 90 ft. above floor level, are shown to great advantage. Twenty-six floodlights are mounted in the choir stalls and chancel, where an illumination of 5.5 foot-candles is furnished. Lighting by superlux lighting units has been furnished in the Library, Chapter Room and Vestries. There is also an efficient system of pilot lighting which serves to illuminate the various stairways to lower ground levels, and to the belfry, organ loft and other offices.

The entire lighting scheme was designed by the Illuminating Engineering Department of the G.E.C., and the whole of the material, comprising fittings and lamps, etc., used by the electrical contractors (Messrs. F. & D. Gillyard Beer, of Ripon), was of G.E.C. design and manufacture. The new lighting of this cathedral, which will doubtless enable its architectural features to be seen much better than under the old conditions, has aroused much local interest.

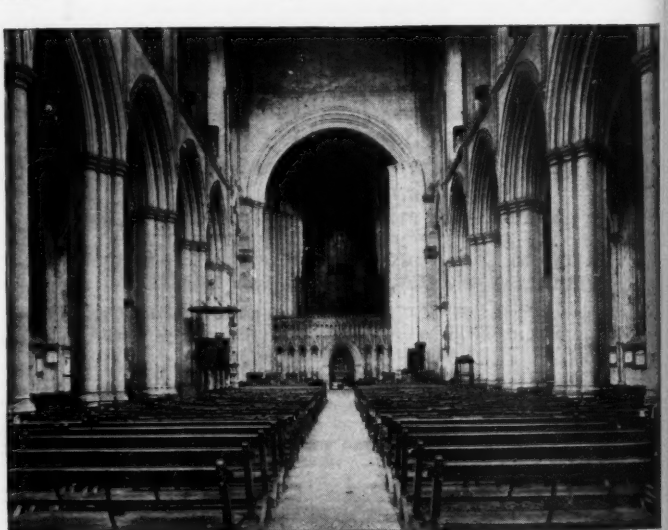

FIG. 2.—The Improved System of Lighting by means of G.E.C. Church Lighting Units and Osram Lamps.

Currency Problems and the Cost of Materials

How far the departure from the gold standard will ultimately affect prices of materials, and consequently the cost of manufactured articles also, is a matter for conjecture. At present, it would appear that, in spite of apprehensions, no appreciable rise has taken place. Messrs. Woodfyt Sales Ltd. write mentioning an impression on the part of some of their clients that prices have been increased. They would like it to be known that so far as possible they intend to retain prices and not to vary discounts. It is hoped that any increase in the cost of materials will be offset by an increased demand for British products.